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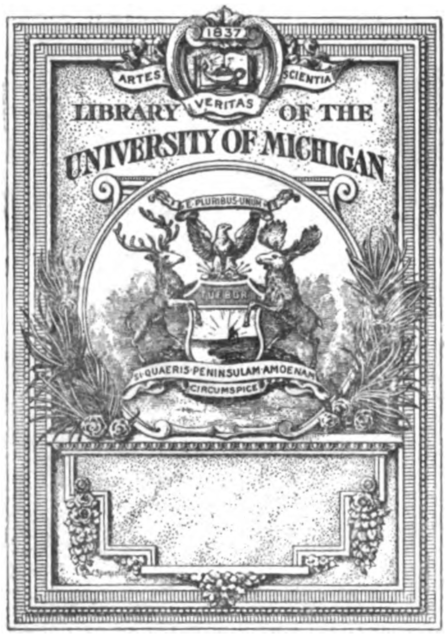
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American Electrician.

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The National Electrical Exhibition.

A GREAT epoch in electrical history was marked by the Paris Electrical Exhibition, of 1881, from which industrial electricity may be said to date. Though arc lighting had already made much progress during several years preceding that exhibition, the entire world was amazed at the showing there made, and the impetus thus imparted to electrical development was marvelous. Next in order of importance was the Philadelphia Electrical Exposition, of 1884, which, among other things, may be said to have resulted in the electric motor being placed in the line of development. While the electrical exhibition now being held in New York, coming as it does at a mature period of electrical advancement, does not hold out hope of such vital results as its earlier prototypes, yet in every sense it is a creditable successor to these two great shows, and outranks most, if not all, the half score of other electrical expositions held throughout the world during the past fifteen years.

From the official catalogue we learn that almost 200 firms are represented, and as very many of these have shared part of their space with others, there are between 300 and 400 exhibits in place, aside from the numerous historical and loan exhibits. While, aside from the Röntgen ray experiments in the practical electrical engineering laboratory, there is nothing startling, as at some of the earlier exhibits, to attract the attention of the electrical visitor, yet, on the other hand, there are few of the crudities which then formed such a large proportion of what was shown. Indeed, one of the most pleasing reflections during a walk through the aisles comes from the visual realization that industrial electricity has now passed far beyond the experimental stage in all of its departments, and rests on a solid basis much different from the shifting one of even a few years ago.

Upon entering the main hall, shown in Fig. 1, one is at once face to face with the attraction which divides honors with the Röntgen exhibit on the floor above—the working model of the Niagara plant operated by power from the machines of the great Niagara original. In the day time the pump which supplies water to the miniature turbines is operated by a small motor taking current from storage batteries charged at Niagara, and at night time by a Tesla two phase motor receiving current direct from Niagara, 465 miles distant, over two Western Union telegraph wires. Here also in the evening can be found an eager crowd awaiting turn to hear through telephones the roar of Niagara, transmitted from a large microphone located by the Falls. Near by is a working model of the Lamb system of electric canal towage, consisting of a long tank of water, in which a miniature canal boat is towed back and forth by electric power.

Facing the Niagara exhibit is the admirable educational display of the New York Edison Electrical Illuminating Company (Fig. 2), by means of which the general public may learn all of the details connected with the domestic use of electricity, its generation and distribution. Here the consumer may see how the current is conveyed from the station into his house; the mysteries of his concealed wiring are laid bare, and a working laundry and kitchen in which electricity does all the heating and cooking, may perhaps cause him to think that without these later applications in his house he is after all, behind the world electrically (Fig. 3). The great arch shown in the illustration is a model of an upper field frame of one of the huge generators in one of the city Edison

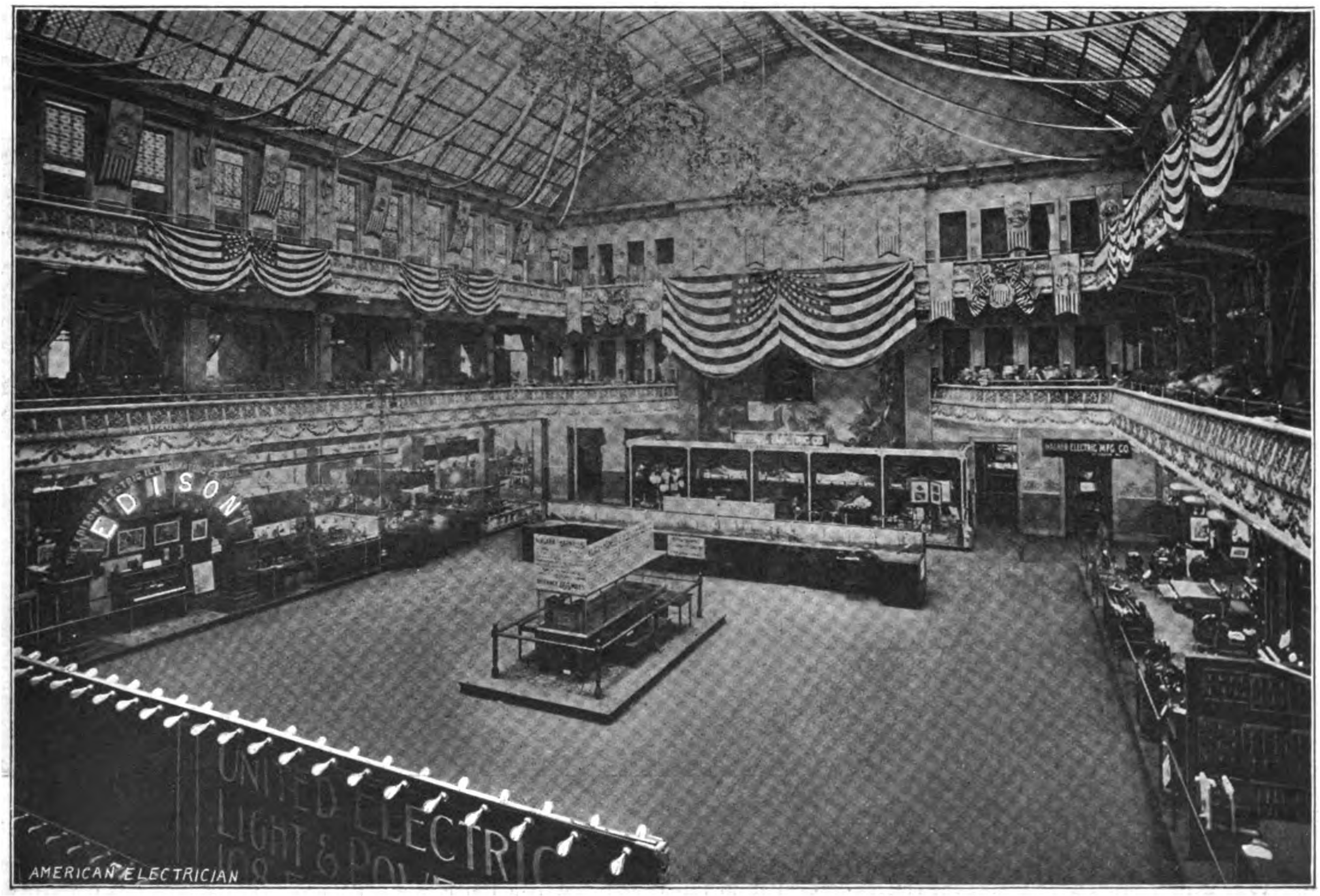

FIG. 1.—VIEW OF MAIN HALL AT THE NATIONAL ELECTRICAL EXPOSITION.

stations. An electric piano, electric bed-warmers, electric surgical and dental machines, are but a few of the other items in this exhibit, which owes its origin more to motives of public spirit than commercial gain.

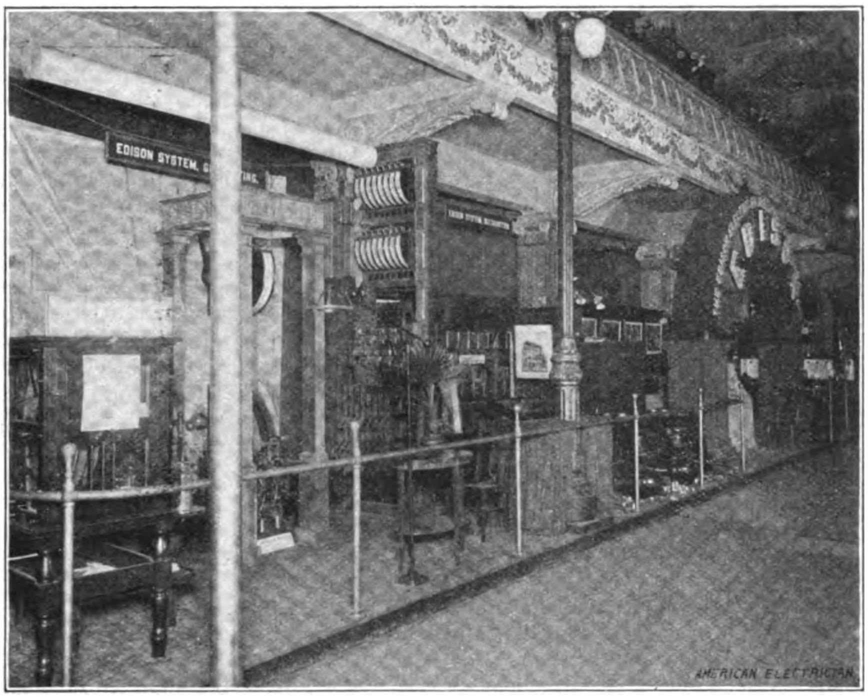

FIG. 2.—EDISON ILLUMINATING COMPANY'S EXHIBIT.

Passing by an electric launch and electric carriage in an adjoining booth (Fig. 11), and descending to the ground floor, we find ourselves amongst engines and dynamos in operation, furnishing current for the manifold uses the visitor notes on the floors above—in one place running a huge printing press and in another producing the wondrous Röntgen rays; here heating a curling iron and there operating a punching press. Following the curious gaze of lady visitors, we see a neatly dressed young woman apparently regarding a battery of Root boilers with some interest, but upon closer investigation find that she is—the fireman in charge!

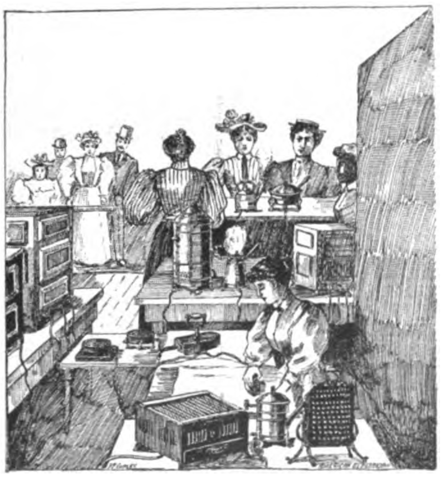

FIG. 3.—AN ELECTRICAL KITCHEN.

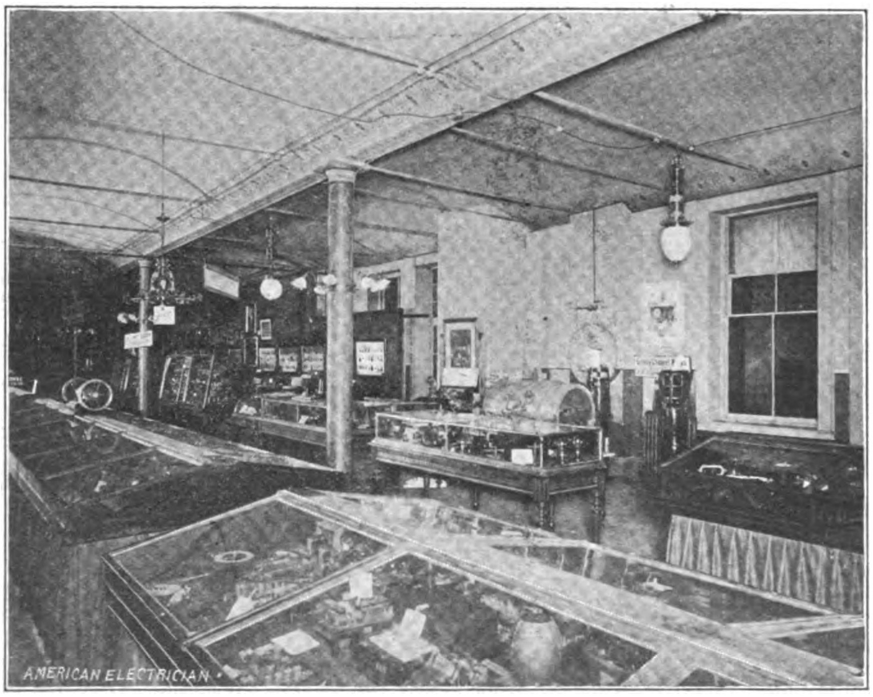

FIG. 4.—PORTION OF HISTORICAL EXHIBIT.

To place the operation of 500 h. p. of boilers supplying steam, in charge of a young woman proves, however, upon examination, to be neither rash on the part of the employers nor a severe tax upon feminine strength nor even inimical to feminine neatness, since the entire working of the boiler is automatic, and merely requires an occasional regulation of a valve on the part of the attendant. The coal by means of a Hunt coal conveyor is brought from bunkers and fed to an automatic Wilkinson stoker, while another Hunt conveyor removes the ashes. The supply of feedwater, from Worthington feed pumps driven by Crocker-Wheeler motors, is automatically regulated by means of Root feedwater regulators, which stop the pump when the water level tends to rise above the normal working level, and start it again when feed is again required. Another interesting exhibit in this department is a Harrisburg "Ideal" engine direct connected to an Eddy generator, which has its frame raised some inches from the floor and merely supported at three points.

Returning to the floor above, the visitor is bewildered by the variety afforded in the trade exhibits. Any notice that would do justice to these would extend over a score or more pages, and not having that space at our disposal, only a few general observations can be indulged in.

The taste displayed in the arrangement of the exhibits is at once noticeable, and at night the brilliant illumination, heightened by the reflection from polished brass surfaces on every hand, adds to the general effect. It goes without saying that the electric light is everywhere pressed into service for ornamental purposes; illuminated signs and decorative effects are to be seen whichever way the eye is directed, their brilliancy, in some cases, unfortunately, defeating the intended end by blinding the eyes of the visitor to the exhibits to which they are designed to attract attention.

In a small room containing the lamp exhibit of the General Electric Company, a panoramic piece, entitled "Mischief Brewing," (Fig. 6) attracts much attention. It represents a witch—rather singularly portrayed, young and handsome—bending over the time-honored caldron and accompanied by the inevitable cat, in this case with fiery (electric light) eyes. Beneath the pot glows a red fire, counterfeited by electric lights, and at intervals fiery sprites appear and disappear in the background. The latter effect is very clever and is accomplished as follows:

The background is painted on a loosely woven fabric or wire screen, behind which are a number of compartments or pigeon holes. The end facing the background of each compartment is closed in with a plate of glass, on which the figure it is to show is painted so as to be largely transparent, and the remainder of the glass covered with an opaque paint. In each compartment is an electric lamp, all the different lamps being connected with a commutator on a motor so as to be lighted only at intervals. In appearance, the fiery apparitions appear as actual part of the background when illuminated, and each distinct from the other, as the walls of the compartments prevent the passage of light except through the painted figure.

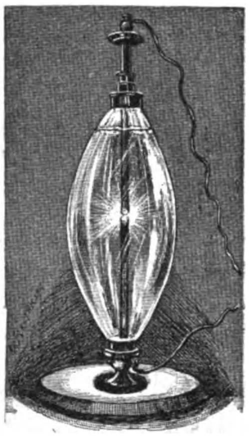

FIG. 5.—ELECTRIC ARC IN WATER.

Another trade exhibit that promises to create a sensation when finished, consists of some hundreds of "bung hole" Imperial lamps so arranged that by throwing in turn a number of switches, different portraits will be outlined by lamps.

In the Weston instrument exhibit is shown an ammeter (Fig. 9) of a capacity of 180,000 amperes, which, we are informed, has been made upon order from an English firm for actual use.

From one standpoint, the historical and loan exhibit (Fig. 4) is intrinsically the most important on view. In a score or more of cases are grouped what is possibly the finest historical collection relating to a branch of applied science that has ever been made, and to Mr. T. Commerford Martin, Dr. Park Benjamin, Mr. Edward Lind Morse and Mr. W. J. Hammer, an unusual meed of credit is due for their public-spirited efforts.

MISCHIEF BREWING.

FIG. 6.—AN ELECTRICAL PANORAMA.

The collection of books of Dr. Benjamin relating to electrical science tells the story of the beginnings of electricity, and are displayed opened at the pages where the first announcements of discoveries and inventions are made. One group relates to ancient knowledge of the magnet and amber, another to the precursors of Gilbert, another to the epoch of Gilbert and the beginnings of the science of electricity. Four other groups bring the chronology down to the time of Franklin, two more to the time of Volta, and a final group deals with contemporary progress in other sciences during the eighteenth century.

Here are first editions and representatives from the great presses of the sixteenth and seventeenth centuries, to excite the envy of the bibliophile, and forgotten volumes whose study by Dr. Benjamin has led to the revision of long-held ideas concerning priority in early discoveries. One of the most interesting volumes is a French work, "Research on Electricity," of which the author is Marat, the monster of the Reign of Terror.

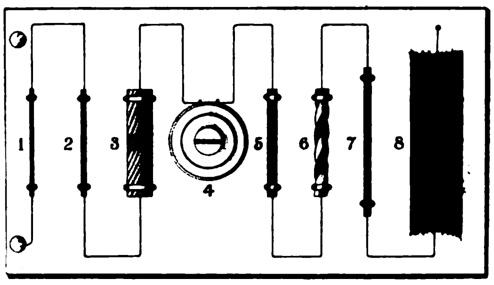

FIG. 7.—HISTORIC ELECTRIC CIRCUIT.

The particular copy of this book on exhibition was given by Marat to the Comte d'Artois, whose cipher and book plate it bears. In a note by Dr. Benjamin it is stated that Marat, at the time he wrote the book, was not the rabid Communist which he afterwards became, but, in fact, was physician to the Count's body guard, and, probably, a very good royalist. Dr. Benjamin adds that the book is peculiar for the looseness of its statements and the impudence of the claims which the author makes to the discoveries of other people.

Adjoining the Benjamin collection are cases containing an exhibit of Morse relics, in which the versatility of the great inventor is illustrated by specimens of his work as an artist and as a pioneer in photography. A painting made when a lad of fifteen shows the great promise of an artist who was lost to art through the superior attractions of electricity, and one of the first daguerreotypes taken in America, here shown, recalls the fact that Morse's name would not be lost to science even had he never taken up electricity. Near by is an exhibit relating to Alfred Vail, Morse's associate in the invention of the electromagnetic telegraph, comprising a model of the instrnment which transmitted the famous message, "What hath God wrought."

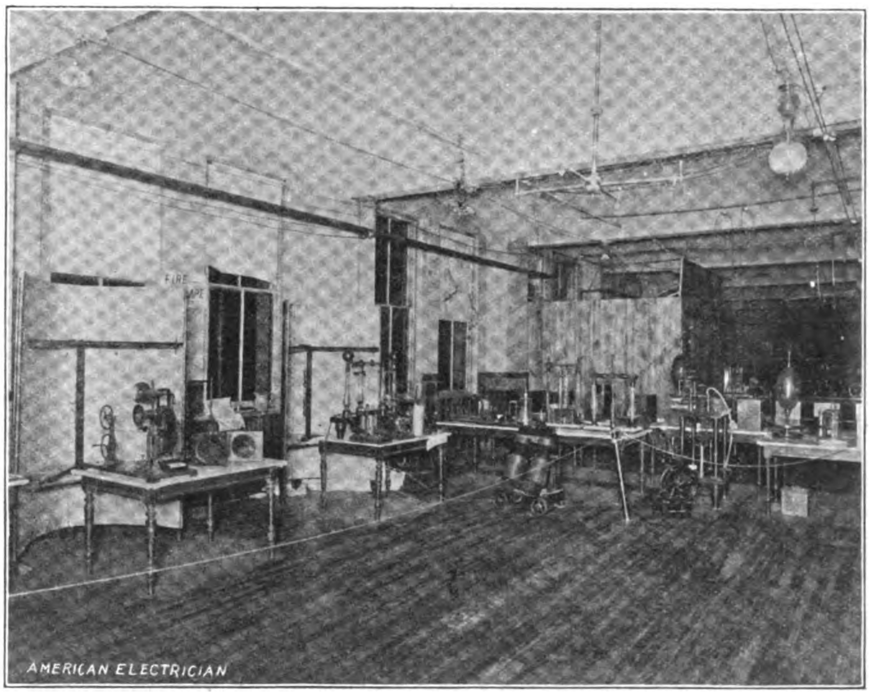

FIG. 8.—PRACTICAL ELECTRICAL ENGINEERING LABORATORY.

The U. S. Patent Office exhibit of 364 models is so bewildering in its richness that one is lost in viewing it. Each in itself is a treasure, and isolated, would command an interest that cannot here be concentrated owing to the multitude of others equally important distracting attention.

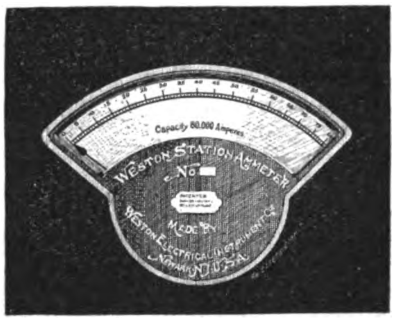

FIG. 9.—A 180,000-AMPERE METER.

The remarkably complete historical collection of incandescent lamps of Mr. W. J. Hammer is one of the most interesting features of the exhibition. Here is truly a "History of an Art," for the hundreds of lamps comprised include, with few or no exceptions, a specimen of every type of incandescent lamp that has been made, in some instances the original lamp itself being shown. Among the numerous other exhibits of Mr. Hammer is a copy of a newspaper printed and sold on a train by Edison when fourteen years of age, some hundreds of photographs of the electrical celebrities of the world, a collection of substances used by Edison in perfecting the incandescent lamp filament, etc. In Fig. 7 is shown a historical electrical circuit through which the current starting the machinery of the exhibition was passed when Governor Morton closed the Greeley golden key on opening night. Among the wires forming the circuit is a section of wire over which Morse sent his first message (1); a section of wire (2) through which the first telephone message was transmitted; a section of the Atlantic cable (3) over which the first cable message was sent; section of a circuit (plug) which lighted the first incandescent lamp supplied from every electric lighting station (4); a section (5) of the first trolley wire, etc.

Among other exhibits in the historical section is one loaned by Prof. Elihu Thomson, comprising fifty different examples of pioneer and typical apparatus, and also a set of apparatus to illustrate investigations in "Repulsion Phenomena"; collections of electrical laboratory apparatus from various colleges; a historical Edison exhibit, comprising the original model of many of his great inventions, etc.

Pages would be necessary to enumerate even the objects of vital interest in this remarkable historical exhibit, and it is with reluctance that the visitor feels obliged to finally pass on. Proceeding up stairs, an interested crowd can always be found about a working "Practical Engineering Laboratory" (Fig. 8), which is presided over by Max Osterberg and a corps of competent assistants. Here all manner of experiments are performed to instruct and interest visitors, among the most striking of which is an arc burning under water as shown in Fig. 5. Here also is the exhibit of supreme interest to both the lay and electrical public—a working Röntgen ray apparatus. A never-ending line of men and women patiently await their turn to have a "glimpse of their bones" through a fluoroscope. During the daytime opportunities eagerly availed of are given to have radiographs taken of afflicted members of the body. The Edison exhibit of Röntgen ray apparatus some evenings is presided over by the great inventor himself, who affably explains its mysteries to visitors.

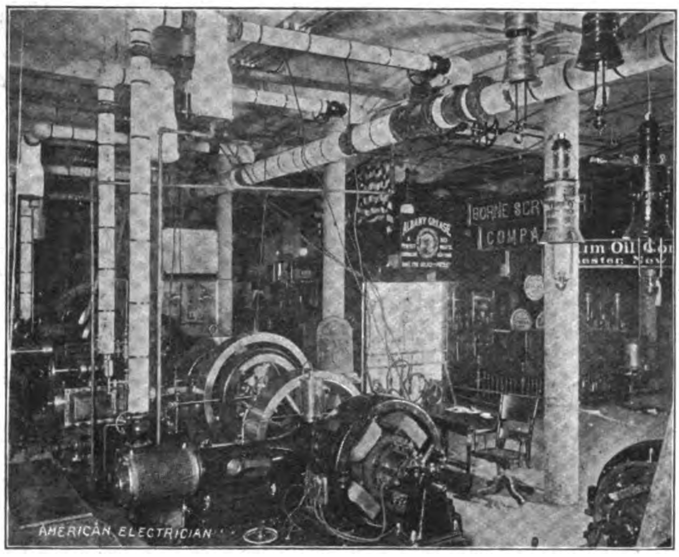

FIG. 10. GENERATING DEPARTMENT.

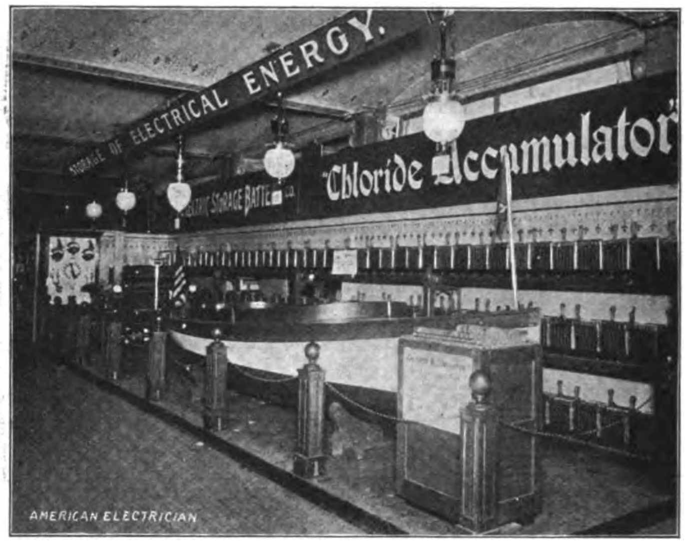

FIG. 11. ELECTRIC BOAT AND CARRIAGE.

Fuse Wires.

BY PROF. W. M. STINE.

This subject is an old one, possibly somewhat threadbare, and needing an apology for again presenting itself to electrical readers; yet as long as the fuse wire is a necessity in the plant, and its peculiarities are not always thoroughly understood, so long must it be discussed.

At the outset it may be asked why the fuse is not as reliable and satisfactory an adjunct to the plant as the incandescent lamp. Herein lies the whole matter, so far as the practical electrician is concerned. Incandescent lamps are so fairly uniform and reliable that one in purchasing them, may be tolerably certain of the product he receives. They have but to be placed in the socket, and the matter is ended. Nothing is left to either the knowledge or judgment of the operator. This definition stamps them at once as a practical engineering device. Any device becomes a practical engineering one in so far as it measures up to this standard. But here lies the whole difficulty with fuse wires. They are as simple, mechanically, as anything can well be, but their action is quite complex and variable. There is no such thing as a standard fuse wire, nor do standard bases and fuse blocks exist. Almost the entire responsibility rests on the knowledge and judgment both of the purchaser and operator. For such reasons, the fuse wire cannot at the present time be regarded as a practical engineering adjunct to an electrical plant. But in very many cases they are a necessity, there being nothing else to take their place. It then remains to place those who must use them in possession of the most reliable information and directions for their use.

It is just here that the electrical engineering profession owes an obligation to those who operate electrical plants. Sufficient experimental evidence is at hand to enable certain standard requirements to be formulated. These would be regulations governing the general design and sizes of fuse blocks, and the proper making of fuse wires on the part of the manufacturers. It is time these questions receive the attention their importance merits.

Fuse wire is purchased on the market stamped with a certain carrying capacity in amperes; the fuse block is also purchased under a vague rating in ampere capacity. If the electrician knows no better, disastrous results may follow the combination of two such unknown quantities. If he has taken pains to post himself, he is no doubt so confused and uncertain that he scarcely knows how to properly fuse a circuit. And no wonder, under existing conditions. No one, unless possessed of considerable knowledge of physics, can properly use the simple fuse wire.

The writer, assisted by Messrs. Freeman and Gaytes, has exhaustively studied the behavior of fuse wires in ordinary use, both from the theoretical and practical standpoint.* Since the publication of this paper, much additional work has been added, and the great variety of the data obtained seems to fully justify the conclusion to be noted.

It must be remembered that the fuse wire is an integral part of the electrical circuit on which it is used, and is subject to all its laws. It differs from the rest of the circuit in having a relatively higher C^2R loss and lower melting point. Its resistance can readily be measured, as well as the current it carries. As a metallic alloy, it has a definite temperature at which it melts. While carrying current, it generates heat within itself, but parts with this heat at a certain rate. All the copper in the line does the same thing, and so far there is no difference between it and the fuse proper. This constitutes the chief danger in the use of such thermal cut-outs, for should they fail, the copper circuit they are designed to protect and the insulation of the circuit as well, may play the part of the fuse. If the heat were generated and dissipated at certain known rates, nothing would exceed fuse wires for reliability and usefulness. They could be adjusted with all the precision of the automatic circuit-breaker or the current-regulator of the arc dynamo.

To understand why this is not the case,

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* "The Rating and Behavior of Fuse Wires," by W. M. Stine, H. Gaytes and C. E. Freeman. Transactions A. I. E. E., Oct., 1895. Reprinted in majority of electrical papers in November, 1895.

attention must be given to the causes of their variable action. Nearly all metallic conductors offer increased electrical resistance as their temperature is increased. These same substances conduct heat in about the same ratio as they do the electrical current, and as fuses are always attached to heavier masses of metal, these attachments constitute, for the most part, the uncertain feature of their action. In addition to such loss of heat by conduction, a further loss results from radiation to surrounding objects and conduction to the air in contact with it. Both the latter losses are greatly influenced by the condition of the surface of the fuse. A bright polished surface on the wire means less heat loss by radiation than would result from the dull, tarnished surface that soon covers the fuse wire.

This may be considered a matter of minor practical importance, but it is associated with a graver effect; The lead in the fuse wire oxydizes quite readily and in the presence of moisture soon coats the fuse with a white covering of oxide and carbonate of lead. Again, this reduces the loss of heat to the air, since the coating is a poor heat conductor. The direct consequence of the tarnished and coated surface is to *retain* more of the heat within the fuse, and as a consequence, it should fuse with a lower current. But everyone who has had much experience with fuses knows that this is just what does not occur; that it in reality requires a *higher* current to blow the coated fuse. But in spite of this seeming paradox, the theory and practice are in exact accord. The outer coating acts mechanically, like a shell, holding the molten fuse in a tube; and the blowing of such a fuse depends not on its melting, but on an explosive action which shall shatter the shell. We have followed this lengthy discussion with a purpose. Some time since, the writer advised renewing fuses after about six months' constant use. By some this statement was considered too emphatic, though it has been warmly supported by the fire underwriters. Abundant data could be given in support of such statements, but it will suffice to state that in actual tests the oxide coating has increased the carrying capacity of the fuse from ten per cent to one hundred per cent. In too many plants coated fuses can be seen which will abundantly support these claims.

Attention must also be called to the sluggish action of the fuse wire. The explanation just given of the action of the fuse makes this matter clear. In the first place, heat is developed in the fuse as a result of the current flow. This requires a certain time. Then the heat is conducted and radiated off, and a balance must be effected between the heat produced and that lost. All heat changes in metals, unless they be excessive, require considerable time. Let us examine a specific case: The fuse wire was of twenty ampere size, and eight inches in length, to avoid all heat losses at the contacts. It blew in forty-five seconds, with twenty-five amperes; in fifteen seconds with thirty-five amperes; in ten seconds with forty-five and in five seconds with fifty-five amperes; while it carried eighty amperes for three seconds. This may be taken as average practice. Note the length used, eight inches. If the fuse had been placed in the block, with a length of about 1½ ins. the carrying capacity would have been enormously increased. This brings us to a consideration of the fuse block itself.

Practically, all of the fuse blocks in ordinary use are both poor in design and dangerous. They have two great faults: the contacts are often placed flush with the porcelain base; this allows the fuse to rest on the porcelain, which, by its cooling action greatly increases the carrying capacity. The distance between the contacts is in nearly all cases too small. For example, a three ampere fuse wire in a covered porcelain block, distance between contacts ½ in., required fourteen amperes to blow it; in an open block, contact distance ⅞ in., ten amperes; while a three inch length in a special block blew with six amperes. We may now draw some conclusions of the greatest practical importance. The sluggish action of the fuse points out that its carrying capacity may be increased to 400 per cent or 500 per cent for a short time. This is an advantage, perhaps, in some cases. If a motor is started up under load, it usually takes an abnormally large current for a few seconds. A fuse will carry this current, while if accurately adjusted it will blow at a much lower current; that is, one slightly above normal working, if the motor is *slowly* loaded. There may be similar cases in which such action is an advantage. However, should the generator be carrying both a lighting and motor load, the starting of a motor of any considerable size will invariably seriously dim the lights. Such action prevents working a generator up to its full capacity, for motor service demands considerable reserve output.

This is such a common experience that it has come to be regarded as a necessity. But any one familiar with the design and construction of motors knows this can be prevented to a large extent. It is possible to so construct the starting rheostat that a motor will never require more than a normal current for starting, unless it is overloaded. The fuse wire is largely responsible for this usual, but poor, practice. For such reasons, rather than for unreliability of fuses, the use of automatic circuit breakers is advisable for motor circuits, preventing abnormal starting currents and enabling generators to be worked up to full capacity on mixed lighting and motor loads. But the sluggishness of the fuse entails another consideration. Take the entire circuit as a whole, and its insulation checks off as a counter-fuse to the actual fuse wire. The weaker of the two will always burn out the sooner under sudden abnormal currents.

In general practice, the marked carrying capacity of the fuse wire and the design of the block are of more immediate concern. In no case, so far as the writer has been able to determine, has the manufacturer marked the product with sufficient data to enable the carrying capacity to be properly inferred. It is only within the past few months that the necessary elements for marking such wires have been clearly determined. The manufacturer has failed from lack of proper knowledge for marking his wires. The proof of such statements is too lengthy to be given here, but the conclusions to be stated are based on full experimental data. It is entirely unsatisfactory to mark a fuse wire with its carrying capacity stated in amperes alone. One may take a five ampere wire, and by placing it in a short block have it carry fifty or even seventy-five amperes for any length of time. To obtain the best results from fuse wires, they must be used under normal conditions. These are, that its length must be sufficient to prevent the contacts from increasing its carrying capacity by their cooling effects; that the fuse be renewed from time to time to insure its being always clean and free from the white coating, and that it be taken into account whether the block is an open or closed one.

A summary of practical conclusions already published by the writer may be again stated:

1. Covered fuses are more sensitive than open ones.
2. A fuse wire should be rated for its carrying capacity for the ordinary lengths employed.
3. On important circuits fuses should be frequently renewed.
4. Fuses up to five amperes should be at least 1½ ins. long, ½ in. to be added for each increment of five amperes capacity.
5. Round fuse wire should not be employed in excess of thirty amperes capacity. For higher currents flat ribbons of four inches and upwards should be used.

Our experiments have shown that for large fuses, a multiple fuse is more sensitive than a single one. A one hundred ampere fuse may be made by taking four wires of twenty-five amperes capacity. The reasons for this are doubtless now apparent.

Too much emphasis has been doubtless placed on the position of a fuse. Unless it be long and quite heavy, its carrying capacity is practically the same whether it be placed vertically or horizontally.

A very large number of alloys have been on the market from time to time. Experience seems to show that the best alloy is one of lead and tin, the lead being considerably in excess. If too much lead is used, the fuses deteriorate rapidly and coat with the white film.

A leading question now is the automatic circuit breaker *versus* the fuse wire. Both these devices are excellent in themselves, but each requires judgment in selection and use. The automatic circuit breaker is to be preferred for switchboard use and motor service. Large fuses should be avoided, as they are both filthy and dangerous. Relegated to the back of the switchboard, the flying molten metal fouls the bus bars and connections, besides coating the board with a sooty deposit. A circuit breaker placed in plain sight on the front of the board is to be preferred in all cases. For lighting circuits, it is doubtful if any simpler and better device than the fuse wire can be used. In spite of all that has been said against it, when properly used and taken care of, it leaves little or nothing to be desired; yet there is nothing about the plant that is more dangerous when ignorantly or carelessly used.

Perhaps the knowledge necessary to use fuse wires properly is too involved to exact from the average central station operator, but these have a remedy from the manufacturer in their own hands. It is reasonable to demand that the manufacturers make the needful tests to determine the necessary constants for their product. They should then mount the wire on copper terminals, and plainly stamp them with the nominal carrying capacity. This procedure leaves no room for mistake on the part of the operator, and besides, would not materially increase the cost of fuses. The Board of Fire Underwriters will doubtless soon require this. They have it in their power to regulate the design of fuse blocks as well, and insist that the terminals be placed the proper distance apart.

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Special Forms of Engine Foundations.

BY E. A. MERRILL.

A requirement generally laid down with considerable emphasis in the specification for an engine installation in one of our modern office buildings, is that there shall be an entire absence of vibration. To secure this not only desirable, but absolutely necessary, result, special precautions are often necessary and the particular type of foundation must be suited to local conditions.

Fig. 1 illustrates a type well adapted for situations where the building foundation is carried to bed rock from which it is necessary to insulate the engine foundation. A brick retaining wall is built enclosing a space somewhat larger than the foundation itself, and the uneven bottom within the enclosure is leveled off with a few inches of sand; then short planks are set on end against the wall and a single layer of brick laid without bond upon the bed of sand; the enclosure is now filled with concrete, constituting the foundation proper, and after it has set, the planks are removed and the space filled with sand; by filling the last few inches with asbestos felt or similar substance, the sand is effectually prevented from working out.

Where the floor consists of a grillage of I-beams covered with a thin layer of cement, the type illustrated in Fig. 2 offers a very satisfactory solution. A brick retaining wall is built enclosing a space sufficiently large to contain the foundation, and about this a floor is built wide enough to give easy access to every part of the engine without stepping down; in fact it raises the floor level to the height of the top of the foundation. The interior of the enclosure—both bottom and sides—is lined first with a layer of asbestos felt or similar material, which should be both a poor conductor of sound or mechanical vibration and indestructible, and then with a single layer of brick; the interior space is then filled with a solid block of concrete.

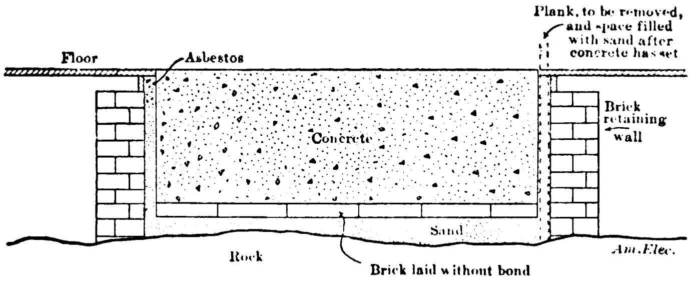

FIG. 1.

With either of these types, various modifications, which will suggest themselves, may be made to suit local conditions. For example, in Fig. 1 it will not always be necessary to carry the retaining wall the full height of the foundation, and in Fig. 4 sand may be substituted for felt, while in both cases brick may be substituted for concrete. The chief advantage of concrete are, first, that for the same bulk it is considerably heavier than brickwork, so that for a given mass the excavation will be less; and second, that a properly made concrete foundation sets into what is practically a solid rock.

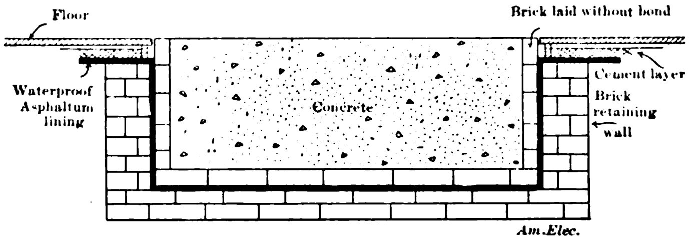

FIG. 2.

For wet locations the question of vibration seldom arises, and in any event presents no difficulty if the construction illustrated in Fig. 2 is adopted. As will be noted, this is essentially the same construction as that illustrated in Fig. 2, with the substitution of an asphaltum layer for the felt and as the former is both vibration and water proof, it effectually meets either or both requirements.

For situations where the conditions present make it undesirable or impossible to build foundations of ordinary depth, or when, in order to get sufficient breadth, it is necessary to build them of irregular shape, the writer has designed a type of foundation constructed of structural steel and concrete, one example of which is illustrated in Fig. 3.

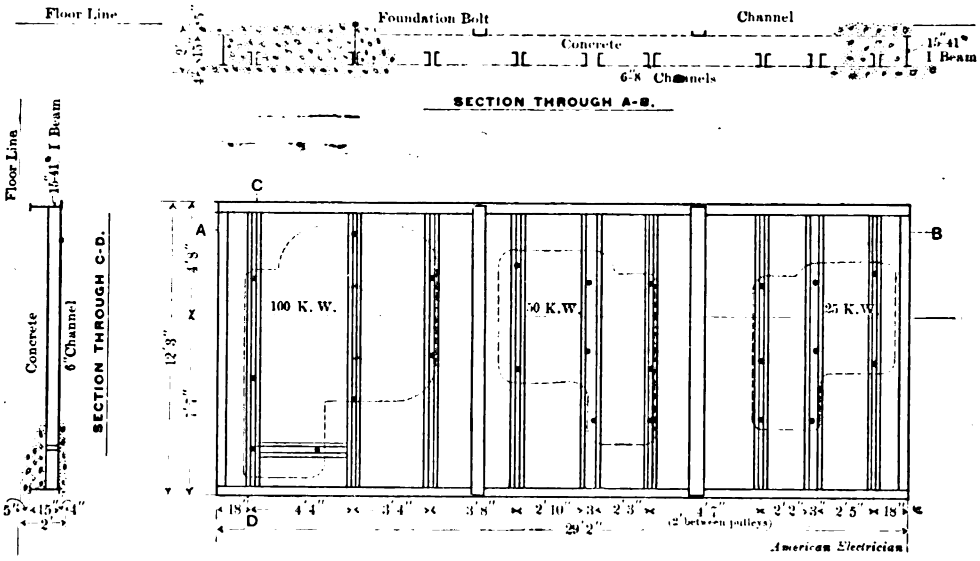

FIG. 3.

Its peculiarity lies in the fact that the foundations are not independent, but merged in one homogeneous structure securely locked in a steel framework, so that each engine unit has, practically, the full advantage of its breadth and mass, and therefore is more securely and firmly supported than on an isolated foundation of ordinary character and depth, or on a single structure of the same depth but lacking the support and strain-transmitting advantages of the steel frame.

Its advantages are the shallowness of the excavation, great stability, moderate cost and the facility with which this form of construction can be adapted to conditions unfavorable to ordinary masonry foundations.

The principal structural features to be noted are the longitudinal beams giving the requisite stiffness for preventing any tendency toward breaking, due to shallowness and unequal loading; the channel beams serving the double purpose of taking the strain of the anchor bolts and securely locking the concrete, so that it is impossible for it to fall out; and the ease with which the steel framework can be built of almost any desired shape to avoid obstructions or to secure economy in material while still retaining the advantages noted above.

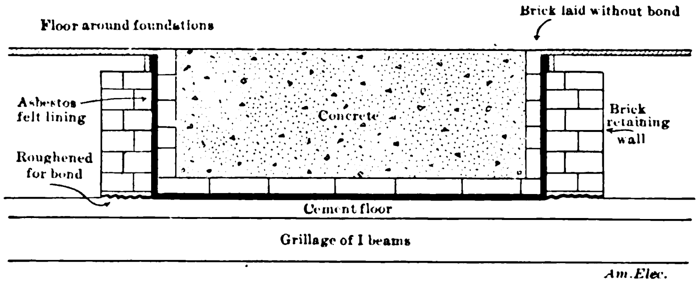

FIG. 4.

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Rare Books.

Among the scores of remarkable publications in the Benjamin collection at the National Electrical Exhibition, are the private and public editions of Galvani's Treatise, with author's annotations, and Ampere's own copy of his famous paper on electro-magnetism, with autographic annotations.

Röntgen Rays.

BY PROF. D. W. HERING.

A discharge in air at ordinary pressure between the poles of a so-called static electric machine or an induction coil, is usually a brilliant white spark or flash, but if wires from the terminals of the apparatus are led into a bulb from which the air is nearly all exhausted, the discharge reveals many features different from those shown in higher pressures. If the vacuum is so complete that only about one millionth of the original quantity of air remains in the bulb, we have the condition of gas upon which Professor Crookes made celebrated investigations, by reason of which such bulbs or tubes became known as Crookes tubes.

The wires sealed in the sides of the tube, with a portion projecting into the interior where they may finally take any desired form, are called electrodes, and are to be joined to the two terminals or poles of the electrical apparatus. The electrode of the tube that is connected with the positive pole of the machine is called the *anode* and that connected with the negative pole the *cathode*. Thus either electrode of the tube may be made anode or cathode, according to the way the tube is joined to the electrical machine or induction coil.

When the machine is excited and a discharge takes place from the electrodes within the vacuum tube, that portion of the tube in reach of rays from the cathode emits a green light known as fluorescence and, besides this, affects the external region in the vicinity as if an invisible radiance of a peculiar nature proceeded from the fluorescent glass in all directions. This external radiance was called by Dr. Röntgen, its discoverer, X rays as a provisional term until the nature of the rays should be well enough understood to make it possible to name them correctly, but the world lost little time in adopting the term "Röntgen" rays as an eminently suitable name. These rays do not, in most cases, illuminate bodies or make them visible as light does, but certain substances when exposed to them in the dark, glow or become fluorescent as does the glass of the tube that is struck by the cathode rays. The property of exciting fluorescence is also possessed by sunlight, but an extraordinary thing about the Röntgen rays is that they are not intercepted by many substances which are quite impervious to ordinary light. The fluorescent Crookes tube may be completely enveloped by a black cloth or opaque case and yet the rays from it will cause a sheet of material rubbed with suitable substances to light up in the dark if brought into the vicinity of the tube. Materials especially suitable for such fluorescent screens are barium platino-cyanide, potassium platino-cyanide and calcium tungstate.

Various substances are penetrable by the rays in various degrees. Metals, especially the denser ones, are very slightly so, aluminum being the most readily penetrated of the metals, and lead and platinum least readily. Wood and organic substances offer but little obstruction to their passage; animal tissues are easily penetrated, but each in its own degree, bone being much more of a barrier than flesh or the organs of the body. Glass, on the other hand, is almost opaque to these rays.

Owing to this difference in penetrability of different materials, if a body of varied structure be placed before a screen which has been prepared with a paste of fluorescent substance, and the rays be directed upon it, they will evidently pass through the penetrable portions and light up the screen where they fall upon it, but will cast a shadow of the opaque portions. In this way the outline of bones within the flesh may be seen, or of metallic objects in wooden or leather cases, the cases being scarcely seen at all. An instrument constructed for convenient application in this way is a fluoroscope.

The rays within the tube from the cathode produce fluorescence of the glass wherever they strike it, and the external radiation can be traced directly to the fluorescent portions as its source. Not that the green fluorescent light shown by the glass is itself the agent that produces effects externally to the tube, for this light, we have seen, may be wholly cut off and still there will be found the mysterious Röntgen rays at work. The action is called radiation because it proceeds from definite centers in all directions, but while producing some of the same effects as light it differs from light in many and marked respects. Light, which proceeds in straight lines, can nevertheless be turned from a straight course at any desired angle by reflection or refraction; light rays can therefore be brought to a focus and their effect be intensified, and images may be produced that are larger than the object or smaller, as we please. Röntgen rays cannot be deviated from a straight path by any means known as yet. Many efforts have been made to do it, and the possibility of reflecting them has been declared several times, but it is yet doubted and the evidences of reflection are by no means convincing. The instances of apparent reflection seem much more like diffusion; as when a muddy stream flowing into a clear lake causes the water to become turbid for some distance on each side as well as in the direct line of the current.

The general interest was much heightened by the fact that the rays not only cast shadows on fluorescent screens, but also affect a sensitive photographic plate. For the cover shutting the plate in its lightproof holder is penetrated by the rays and the shadow effect is produced on the plate within.

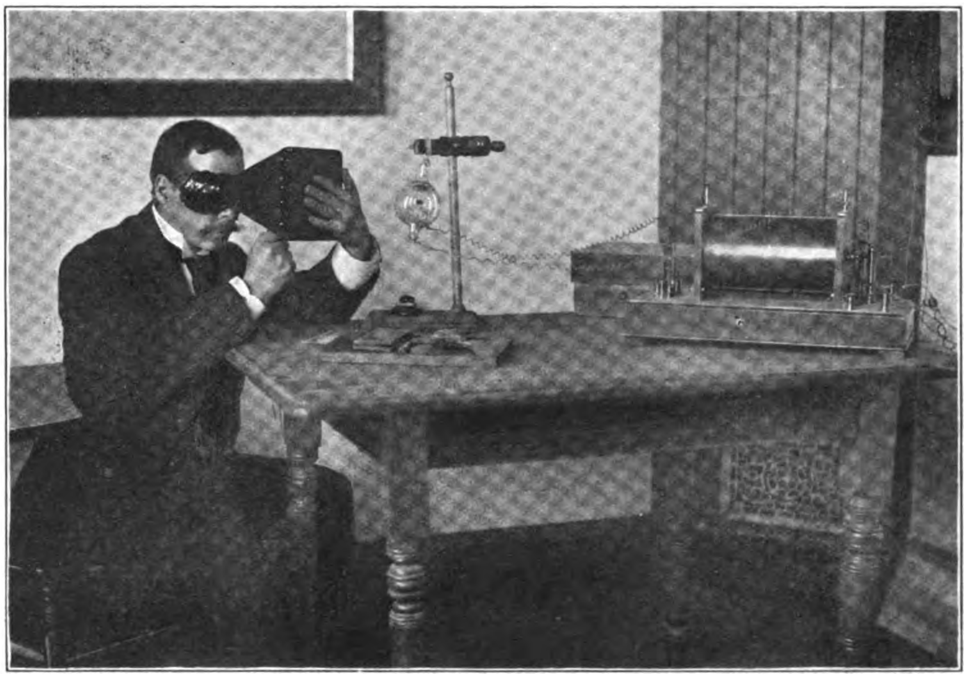

FIG. 1.—RÖNTGEN RAY APPARATUS.

The foregoing is a general statement of the Röntgen phenomena. The most common method of producing Röntgen rays and of observing their effects is illustrated in Fig. 1, where the terminals of the Crookes tube are seen joined to those of the secondary wire of the induction coil; the photographic plate enclosed in its holder and surmounted by the objects to be pictured is immediately beneath the tube; and the use of the fluoroscope (of the form invented by Mr. Edison) in observing the structure of the hand is shown on the left. A high vacuum in the tube is necessary, a pressure of about one-millionth of an atmosphere being very effective. If a tube thus exhausted is not more than two inches in diameter and the terminals inside are within an inch of each other, it will give fairly good Röntgen effects with a coil that would produce a spark of one inch or more in air. A higher vacuum is better, but then a higher electric potential is necessary and a rapid and sudden interruption of the primary current is required. With a large tube, say, six to eight inches long, and a high vacuum, the coil should be capable of producing a spark of six or eight inches, and the current interrupted fifty times or more per second. Excellent effects are obtained by using the Tesla or oscillatory disruptive discharge due to rapidly alternating charges of extremely high potential.

As the source of the rays is necessarily a considerable portion of the surface of the tube, it is plain that a sharp outline cannot be produced unless the object is very close to the screen or plate, or else the tube is at a considerable distance away. If the object is small and even within a half inch of the plate, a large tube would send rays into the space between the object and the plate, and the shadow would be lost. Thus there are severe mechanical limitations to the experiment.

FIG. 2.—RADIOGRAPH OF VARIOUS ARTICLES.

Fig. 2 shows a variety of objects taken with the same exposure. There is a steel gauge in a morocco case, a fountain pen and filler in their cardboard box, a coin and amber mouthpiece in a round wooden box, a lead pencil with metal cap and a pincushion.

Immediately upon the first announcement of the extraordinary discovery, attempts to repeat the experiment were made throughout the world. Efforts were especially directed to making the discovery serviceable in medicine and surgery, a great impetus in this direction being due to the startling famous picture of the living hand, revealing distinctly the bones and joints in a hazy envelope of flesh. The hand has been a favorite subject to try upon, and other portions of the body have been successfully examined by means of the rays. A less common, but not less interesting, picture is Fig. 3, which shows the hand and arm of a very young baby. Here are seen the beginnings of the bone formation, the centers of ossification from which the bones grow while their form and size are as yet incomplete. The original picture shows all of the details with great distinctness, but these are much blurred in the reproduction, the engraving process not being able to reproduce the delicate shadows of the photographic print.

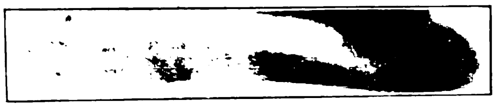

FIG. 3.—RADIOGRAPH OF A BABY'S ARM.

The advances that have been made since the first announcement of the discovery may be summed up briefly about as follows: (1) improved methods of operating; (2) reduction of time of exposure to obtain an impression on photographic plate—whereas the first attempts required one to two hours, now under best conditions a good picture can be obtained in a few minutes, instances being recorded of an impression being obtained in less than a second; (3) determination of the source from which the rays proceed; (4) knowledge of the electrical effect of the rays upon bodies receiving them, non-conductors being made conductors by them. In addition to these, some points which were at first accepted without hesitation are now considered open to question and, singularly enough, the most doubtful one is as to whether the transmission of the action from the source to where the effect is produced is in the form of waves of any kind, and therefore whether there are any rays in the case at all, in the sense in which the term is commonly used in science.

These additions may seem small in comparison with the magnitude of the discovery itself and the work of the discoverer, and they are so, but when it is remembered that investigators had to repeat Dr. Röntgen's experiments before reaching a point from which to advance, that they worked independently, and therefore often duplicated one another's work, that their laboratories were at first indifferently equipped for such experimentation, and that in few if any instances could they devote all or even a considerable portion of their time to this one line, the results reached within four months speak well for the zeal and intelligence of the workers.

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Crookes Tubes and Experiments With Roetgen Rays.

BY THOS. DUNCAN.

After using a Crookes tube a number of times it was observed that it required a greater electromotive force to operate it. This phenomenon has been noticed by several experimenters with Crookes tubes recently, but has been known for years to incandescent lamp makers.

If the vacuum of an incandescent lamp be tested by means of a spark coil when first made, and is found to show a luminescence inside, after being put in circuit and used for a month or so, it will be found upon trying it again with the spark coil, that little or no luminescence will take place with the original pressure or spark length. The writer has even found this to take place when a new lamp is subjected several times to a voltage double of that for which it was designed. The duration of contact must be very short or as nearly instantaneous as possible, not only to protect the filament, but also to prevent the interior of the bulb from being blackened.

I have also prepared lamps in this way for comparison with other makes, when showing intending purchasers the difference between the vacuum obtained in the lamps I represented and those sold by other makers. It undoubtedly shows that there are tricks in all trades.

The theory I always entertained regarding this increase in the rarefaction of the lamp was, that when incandescence takes place, the remaining air combines with the vaporized carbon particles or molecules that are undoubtedly thrown off from the filament, and is precipitated as a solid upon the interior surface of the receiver or bulb.

How far this theory involving chemical change with resulting precipitation can be applied in the case of Crookes tubes, I am unable to say, but would be inclined to think, as Prof. Elihu Thomson has suggested, that the improvement in the vacuum of the Crookes tube is due to the carriage of metallic aluminum or other metal forming the electrodes, to the sides or interior walls of the bulb, the residual gas being absorbed in so doing.

The success attending the production of good skiagraphs depends more upon the degree of rarefaction of the tube than anything else, and can be verified by any one who has had the misfortune of trying to obtain Röntgen rays from domestic tubes, or those made by makers of incandescent lamps.

It is possible that good Crookes tubes will be turned out upon the market by lamp makers, but it is to be regretted that some of these have been making and selling for the past month or two tubes that are as unfitted for the purpose intended, as their makers are to represent Professor Crookes in a mental capacity.

I have tried eight Crookes tubes made by four different incandescent lamp companies, but with only one tube could I obtain any good results, the vacuum in the other seven being so low and poor that it was useless to experiment with them. They did not seem to have any better vacuum than that shown by an ordinary incandescent lamp. The one tube which bore all the characteristics of a genuine Crookes tube was made by a St. Louis Company, and if all their lamps are exhausted in as thorough a manner as exhibited by this tube, they must undoubtedly receive credit for it.

There seems to be one thing certain, and that is, if any one undertakes to make Crookes tubes for skiagraphing through opaque matter, they will have to improve upon the ordinary practice and methods employed in exhausting lamps.

The very first step to be taken is to see that the pump is as clean and dry as it is possible and practical to make it. This may partially be accomplished by preventing moisture from entering either the mercury or the high vacuum chambers (mechanical or automatic Geissler pump), by causing the outside air which enters the mercury chamber at every operation of the pump, to pass through granulated calcium chloride, and interposing between the high vacuum chamber and the bulb to be exhausted, some anhydrous phosphoric acid, which has a great affinity for moisture. In the latter precautions the introduction of the anhydrous phosphoric acid prevents any moisture that may be contained in the bulb to be exhausted from passing down into the high vacuum chamber and coming in contact with the mercury. It must be remembered however that the anhydrous acid must be renewed often and not allowed to form a surface film or crust on top, when it is useless.

The foregoing suggestions are well known and understood by makers of incandescent lamps, so are given more with the view of assisting and aiding the casual reader who may not be so well informed or initiated into the precautions necessary for the production of high vacua.

If an incandescent lamp be exhausted until no air can be seen escaping through the valves of the pump, and the filament then incandesced, considerable quantities of air will be expelled at each operation of the pump, thereby showing that this air has been occluded in the pores of the carbon filament, and could not have been gotten rid of without heating the filament and driving the air out into the vacuous space surrounding it.

This heating also assists in drawing off the air which clings or adheres against the glass upon the inside of the bulb. Therefore in exhausting Crookes tubes, I should think that it would be good practice to smoke the bulb thoroughly upon the outside, then set an oil lamp or other source of heat under it, at the same time covering it over with an asbestos hood also smoked upon the inside, in order to concentrate the heat and distribute it as evenly and efficiently as is possible. This would help to remove the air from the inner surface of the bulb.

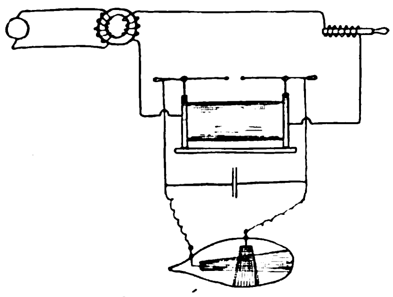

FIG. 1.

If the electrodes are made from aluminum or other porous metal, the secondary terminals from a spark coil can be applied to them, and set in operation in a similar manner to that in which the tube is to be used afterwards. This can not help but be a ready and satisfactory means of eliminating the air occluded within the electrodes.

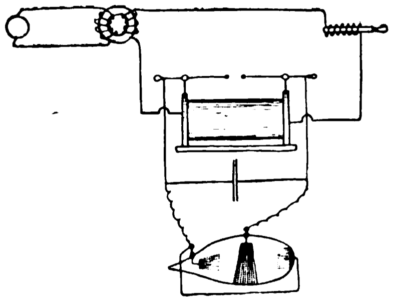

FIG. 2.

When we consider that mercury evaporates so readily even at ordinary temperatures, it might be admitted that a certain amount of mercurial vapor gains admission to the bulb, but even this may be prevented by interposing in the tube connecting the high vacuum chamber and the bulb being exhausted, a small quantity of iodine (next to the high vacuum chamber) which absorbs the mercury vapor, then some sulphur which in turn absorbs any vapors given off by the iodine, and lastly powdered silver, which completely absorbs any sulphurous vapor that may be evolved. This method of getting rid of the mercurial vapor has been employed by Professor Crookes himself, in connection with measuring the degree of rarefaction obtained with a Macleod gauge.

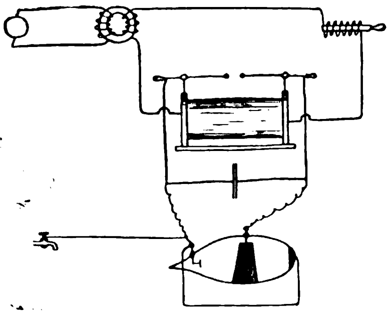

FIG. 3.

While experimenting with a Crookes tube, I noticed that a cathode stream was thrown off from both electrodes, due to the current used being an alternating one. With the object of trying to suppress one of them and increase the density of stream from the other, I tried the following experiments, which may prove of some interest to those experimenting in the production of Röntgen rays.

The current employed was the ordinary high frequency alternating current, making about 16,800 per minute, corresponing to a frequency of 140 periods per second.

The induction coil was capable of giving sparks up to eight inches; the primary was supplied from the secondary on a one hundred volt transformer, and had an inductance coil in series, so that any current strength could be obtained from the transformer, depending upon the length of spark required. A condenser was employed across the terminals of the secondary of the spark coil, as shown in Fig. 1.

When an electromotive force was applied, the usual yellowish green fluorescence appeared all over the interior of the bulb, each stream also casting a dark square spot upon the wall of the glass opposite the electrode from whence it proceeded. The square form of the dark spot was due to the electrode having a square surface.

Upon applying an external electrode of tinfoil, about the size of a silver dollar, to the end opposite the electrode whose cathode stream was thrown out horizontally, or across the greatest length of the tube, and then connecting with the electrode, it appeared to throw off a counter stream which perceptibly diminished the density of the stream from the inner or opposite electrode. This was also accompanied by a reduction in the fluorescence at the ends of the tube, and by an increase of the stream thrown off by the remaining or upper electrode, which in turn produced a marked increase in the fluorescence upon the opposite side of the tube. This arrangement is shown in Fig. 2.

When the hand was brought in contact with either or both of these end electrodes, the respective streams of cathode rays and resulting fluorescence were again reduced to a very marked degree, with an accompanying increase in the stream thrown off by the upper electrode.

This last result naturally suggested grounding the end electrodes, which was done by connecting to a water pipe; the experiment was then complete, the upper electrode throwing off a very strong and dense beam of cathode rays, causing the opposite wall to be very bright with fluorescent light, while the two other electrodes were as inactive looking as if they were not present at all. This arrangement is shown in Fig. 3.

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Electricity and Corsets. The introduction of an electrical course in the Oakland (Cal.) Girls' High School has resulted in unexpected perturbations, both feminine and magnetic. According to the New York *Sun*, the professor in charge of the electrical laboratory has had a distracting experience, for during the lessons the delicate instruments have played him all sorts of tricks, and all his experiments have been of doubtful success. Every once in a while a girl would step up to tell what she had learned about volts, ohms and amperes, and immediately the galvanometers would gyrate wildly and the needles on the various dials would wabble, and all the laws of Volta and Ohm and Faraday would go to smash, and the findings of Edison, Tesla and Moore would become strangely lost. Inspecting the cause, the professor enlisted the aid of some of the women teachers, who counseled the girl pupils to discard corsets, at least before they take lessons in the electrical department. Finally, it was found necessary to issue a rule barring corseted girls from this department, and the embarassing question as to how its violation may be determined has been neatly solved. In entering the electrical department the girls have to pass by a sensitive magnetic instrument, besides which an attendant is stationed. On the near approach of a girl wearing steel ribbed corsets, the needle gyrates frantically, and the girl is respectfully, but firmly, reminded of the rule, and expostulations are useless. The five hundred girl students, says the *Sun*, are seriously disturbed over the situation, and as a body are not yet decided as to whether electrical science is of sufficient importance to justify a sacrifice of such a cherished object of feminine apparel as the corset.

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Stealing Electricity. That in the heart of a city connections can be made to an overhead electric railway feeder and for months current stolen for lighting incandescent lamps in saloons, seems improbable, particularly in view of the fluctuation in the lights incident to this system of supply, which, it would seem, should soon excite suspicion and lead to detection. Yet in Brooklyn several saloons were lighted by current thus stolen from the Brooklyn, Queens County & Suburban Railway Company during a period of a year. The theft was detected through a tree in front of one of the saloons taking fire, supposedly from a trolley wire coming in contact with it. Linemen sent to repair the leak found that a wire led from the saloon window to a tree, but it was claimed by the saloon keeper that the wire, which passed around the trunk, was a guy to support the tree. It was discovered, however, that the wire also passed through a hole bored through the tree at a higher point, that a nail had been driven into the railway feeder and the supply wire attached to the nail! In order to obtain incontrovertible evidence, it was arranged to shut off the current at the power house for three seconds at three specified times during the evening. At 9:00, 9:15 and 9:30 p. m. the lights went out and the saloon was in darkness for three seconds each time. The inspector, much to his astonishment, also noticed that the lights in two other saloons went out simultaneously with those in the saloon under investigation. Upon further investigation it was learned that two young men about a year ago had put the electric light in the several saloons referred to, and collected monthly half the former gas bill.

Ornamental Electroliers.

WHAT the United States take the lead in the design and manufacture of artistic electroliers is a statement that might seem hazardous, though some well qualified to speak believe it can be easily maintained. In isolated cases it is undoubtedly true that the French and, occasionally, the English, produce designs of the highest artistic merit, but of recent years in this country the demand for special designs, brought about by the lavish decoration of magnificent private residences and luxurious hotels and the recognition of the artistic element in the embellishment of public buildings, has led to a development of which the general public is little aware.

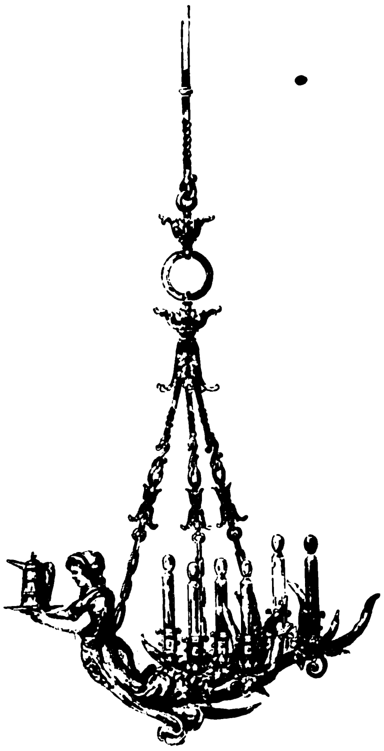

FIG. 2.—DUTCH CHANDELIER.

The stock designs of American fixture manufactures as illustrated in trade catalogues, though they compare favorably with those represented in similar publications of foreign makers, give but little indication of the special work done in this line, as the more artistic designs never appear in the pages of these. Owing to the very considerable expense involved in getting up such designs, manufacturers are loath to place them at the disposal of their competitors, and consequently it is rarely that they are illustrated in print; in many cases, indeed, a drawing is destroyed after the corresponding fixture has been made.

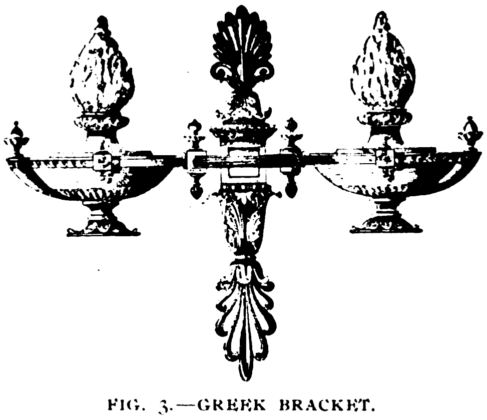

FIG. 3.—GREEK BRACKET.

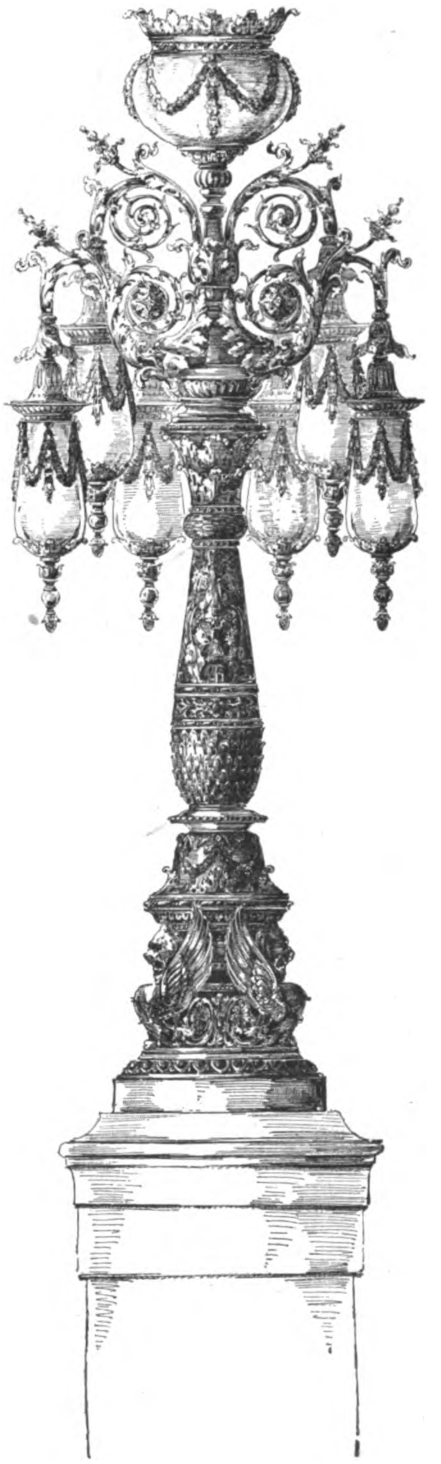

FIG. 1.—BRONZE STANDARD.

Of the special designs for fixtures, some originate with the artistic staff of the manufacturer, others are furnished by those having charge of the decoration of a building, and still others are especially prepared by an independent artist, sometimes of national reputation. All of the more important firms manufacturing fixtures have drawings of "exclusive designs," generally of an expensive character, which are not published but from which fixtures are selected for manufacture by customers; in order that the design may not be "cheapened" these are not kept in stock. The same firms also furnish original designs to suit the requirements of purchasers, in which case the designs may or may not be subject to reproduction for others.

The tendency of the present day in the decoration of more expensive residences and of magnificent hotels like the Auditorium of Chicago, the Walton of Philadelphia and the Waldorf or Netherlands of New York, is toward individualization in rooms and apartments. Dutch, Louis Quinze, Empire, Flemish, Persian, classic and other styles of decoration for parlors, suites and public rooms, are nowadays in most cases carried out faithfully in all details, and *carte blanche* most frequently given as to expense. Not a small part of the effect depends upon the lighting fixtures harmonizing with the general design of the room or apartment, and to the incentive thus supplied the great artistic advance in American fixture making is largely due. In a room with mural paintings by an academician, or with sculptures or wood carvings that have nothing akin to commercial work, the design of the appropriate fixture is a matter, it goes without

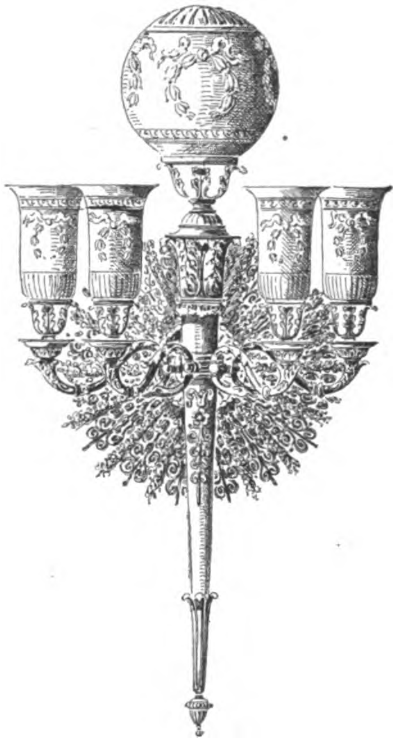

FIG. 4.—EMPIRE BRACKET.

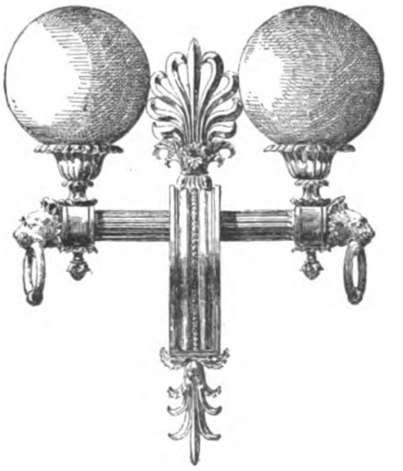

FIG. 5.—CLASSIC BRACKET.

saying, which calls for a high order of artistic skill, and it is creditable indeed that in no particular does the domestic design and execution fall short of a degree of merit that might well tax the ability of designers in European countries usually regarded as much in advance of this country in artistic work in general.

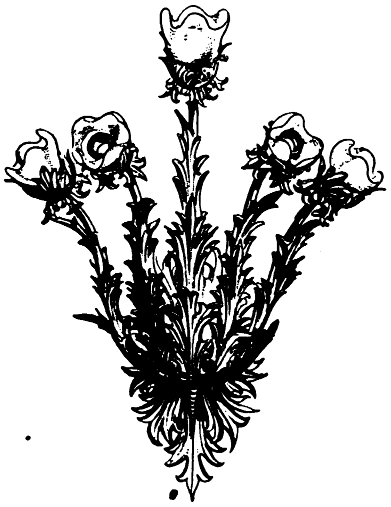

FIG. 6.—THISTLE BRACKET.

Through the courtesy of several leading manufacturers of artistic fixtures, we are enabled to illustrate a number of special designs, many of which were prepared to conform to general decorative schemes. The reproduction in Fig. 1 shows a beautiful design of a combination fifteen light standard, one of a pair executed in bronze for the magnificent office building of the Metropolitan Life Insurance Company, Madison Square, New York. As will be seen, the artistic appearance is not marred, as is often the case, by the gas attachments, which in this instance are in the form of ornamental branchings. The six light chandelier shown in Fig. 2 was designed for the Dutch café of the Waldorf Hotel, and is fashioned in wrought iron and stag's horn, the figure being carved in wood.

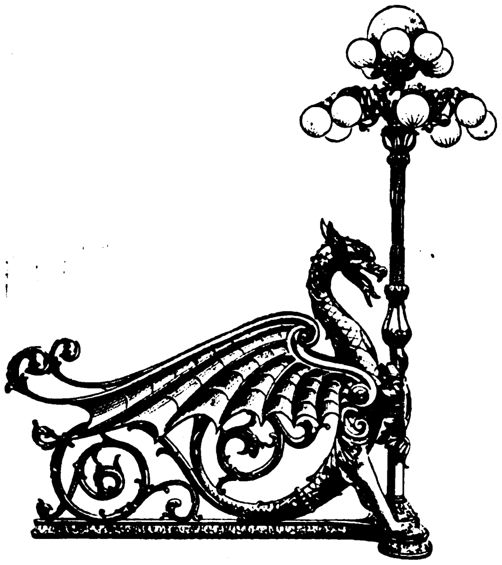

FIG. 7.—GRIFFIN STANDARD.

A five light bracket is shown in Fig. 4, designed for a large banqueting room, the style being Empire in detail. The back plate is particularly elegant in appearance.

Fig. 5 is a two light classic bronze bracket made for the hallway of a club house. The Greek bracket shown in Fig. 3 is combination fixture, though nothing in the design would indicate it except by close inspection. The electric lights are in the center under the flame-like globes, the emergency gas tips being at the extreme right and left.

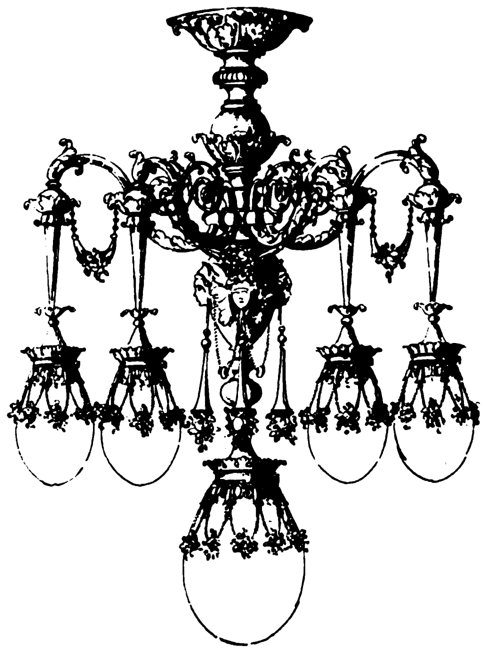

FIG. 8.—ITALIAN RENAISSANCE CEILING FIXTURE.

Figs. 10 and 11 are fixtures installed in the Metropolitan building above referred to, both being executed in bronxe. All of the above fixtures were made by the Mitchell Vance Company, New York, to whom we are indebted for the use of the original designs for engraving.

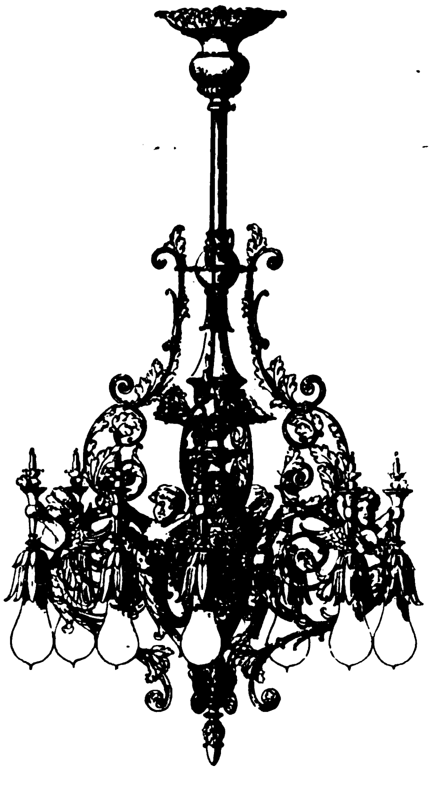

FIG. 9.—ITALIAN RENAISSANCE CHANDELIER.

Figs 8 and 9 show two chandelier designs in Italian Renaissance. Both fixtures were finished in Roman gold, which style of finish is well adapted to, and much used for, higher grade work. We are indebted to the Chicago General Fixture Company for permission to reproduce these two designs.

As one enters the magnificent office rotunda of the Hotel Netherland, New York, his attendance is immediately attracted by a pair of great bronze griffins guarding a stairway leading to a lower floor, at the same time forming part of the design of two great standards carrying almost a score of electric lights within spherical globes. One of these is shown in Fig. 7. This striking design was made by the architect, W. H. Hume, and executed in polished bronze by John Williams at his factory on West Twenty-seventh Street, New York. Fig. 6 is a thistle bracket made by the same firm from a design by Mr. Hume, and is one of a number used in one of the principal public rooms of the magnificent Hotel Netherland, one of the Astor hotels in New York city.

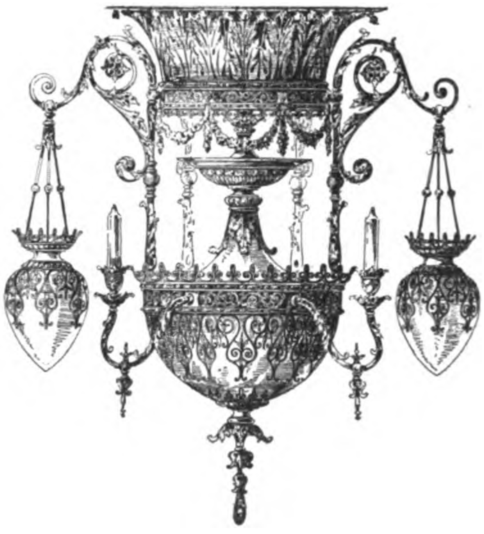

FIG. 10.—BRONZE CEILING FIXTURE.

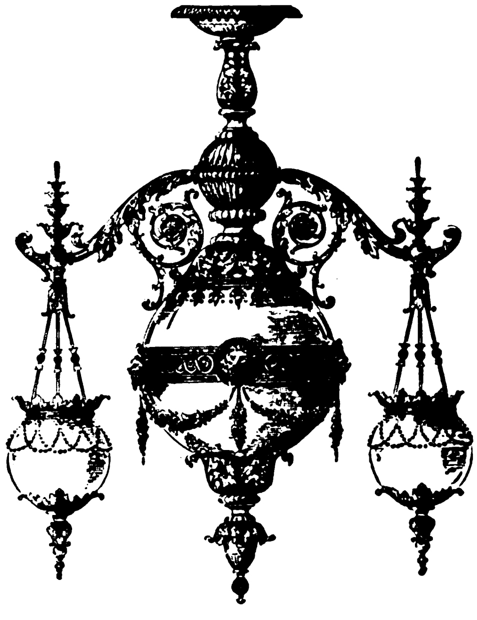

FIG. 11.—BRONZE CEILING FIXTURE.

NATIONAL Electric Light CONVENTION.

The Nineteenth Convention of the National Electric Light Association held on May 5, 6, and 7 at the Grand Central Palace, New York City, though hardly as well attended as some of the previous conventions, was yet in many respects a decided success, the character of the papers being somewhat above the average.

The reason for the lesser attendance seems to lie in the fact that the large contingent from New York and adjoining cities, which usually goes to swell the list, was not regular or constant in its attendance; in addition, the numerous attractions of the city and the large number of out of town delegates who had business to transact in New York and vicinity, tended to reduce the number of attendants on the sessions. Owing to several of the papers not having been handed in in time to be put in type before they were read, a motion was passed that all papers hereafter must be submitted to the executive committee for approval and be printed and forwarded to the members one week before the meeting of the convention. If the papers are printed in time, it is proposed to read them by title only except in special cases.

FREDERICK NICHOLLS, PRESIDENT N.E.L.A.

In his presidential address Mr. Wilmerding sketched the growth of the electrical industry and referred to the great object lesson which the exhibition held in connection with the convention afforded on this score. About seventeen years ago, he said, the first central station was established, and at present there are 2500 electric light companies in the United States and about 200 municipal plants, representing an invested capital of over $300,000,000. An idea of the capacity of these, together with those of isolated plants, may be formed from the fact that there are produced daily for their use from 50,000 to 75,000 incandescent lamps, while the annual consumption of carbons in arc lamps is 200,000,000.

Of electric railways there are no less than 900 in this country, using 11,000 miles of track, operating 25,000 cars and involving an investment of $750,000,000, which is increasing annually at the rate of $100,000,000 for new roads and new equipment. Against 900 electric railways in this country, there are less than 100 in all Europe, and as to electric lighting, the output of a single company in New York or Chicago is greater than the output of all the stations in the city of Paris. President Wilmerding referred favorably to the work of preparation of a set of new rules for safe wiring, whose adoption, when finished, throughout the United States, he considered would be a great boon.

Among the business matters discussed by the Association, several subjects developed more than usual interest. When the matter of appointing a delegate to the National Conference on Rules for Safe Wiring came up, ex-President Armstrong strongly opposed committing the Association by appointing a delegate as member of the Conference; President Wilmerding and others favored such action, but finally a compromise was made by appointing a committee of five to co-operate with the National Conference, and with authority to elect one of its members a delegate — the Association by this action not committing itself to any rules that may be adopted.

The Committee on Data requested to be discharged, as it felt that the present method of procuring data did not produce satisfactory results, owing to lack of reliability. The chairman, Mr. Swetland, proposed that the Association obtain the services of an expert to thoroughly examine into the cost of operation of certain sample plants, selected with a view to securing average results, his report to take the place of the present report of the Committee on Data. After some discussion this suggestion was adopted, and the necessary expenditure of money by the Committee on Data for the services of an expert was authorized.

Some dissatisfaction was expressed that the Committee on the Relations between Manufacturing and Central Station Companies made no report, and after some discussion the discharge of the former committee was authorized with the understanding that a new committee should be appointed.

A discussion took place in regard to a standard of light, and a committee was appointed, consisting of Dr. Louis Bell, chairman, James I. Ayer and Louis A. Ferguson, to confer with the American Institute of Electrical Engineers for the purpose of determining such a standard.

The following officers were elected for the ensuing year: President, Frederick Nicholls, Toronto, Can.; first vice-president, Henry Clay, Philadelphia; second vice-president, J. J. Burleigh, Camden, N. J.; members of the Executive Committee: A. J. De Camp, Philadelphia; John A. Seely, New York City; A. M. Young, Waterbury, Conn. and H. A. Wagner, St. Louis, Mo.

Below are given abstracts of all the papers read except that of Mr. W. L. R. Emmet, which will appear in a following issue.

EQUALIZER SYSTEMS OF DISTRIBTTION.

In a paper with this title, A. Churchward described a number of systems that have been devised to accomplish the same results obtained with the usual three wire system, including one of his own for this purpose, which has been in successful operation for two years. Referring to the accompanying diagram, *A* is the generator across whose leads is connected a motor *B*, with two commutators, *E* and *F*; *C* is the field circuit of the motor. The generator circuit is connected with the motor by a brush on each commutator; two other brushes, one on each commutator, are connected together and an equalizing or neutral line run from them, as shown in the diagram above. When the heaviest loads are on this system and the sides are balanced, the equalizer merely runs free as a motor. Should one side contain more lamps than the other, an amount of current will flow between the armature and the equalizer wire sufficient to take care of the overbalance, the operation in this respect being exactly similar to that of the Edison three wire system.

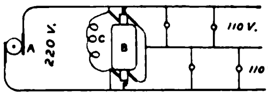

DIAGRAM OF CIRCUITS.

The same principle can be applied, for example, on a 500 volt line, forming four 125 volt lighting circuits, and yet permitting the motor load to be carried at 500 volts.

In the discussion of Mr. Churchward's paper, Mr. Edgar, of the Boston Edison Illuminating Company criticised adversely the system described, in which he said that the motor equalizer would be required to have a current capacity equivalent to the total current capacity of the station. Mr. Churchward answered that this was not so, as a very slight wire would stand a tremendous current, and that the equalizer would stand an overload. The point of the system he said, was primarily to get around the Edison three wire system. It is intended to put the equalizer on every block and not in the station, the method being one of getting around the three wire system irrespective of economy.

INDUCTOR ALTERNATORS.

In a paper entitled "Some Account of the Evolution of the Inductor Alternator," John F. Kelly traces this type of generator from 1854 to the present type, describing in detail some of the more characteristic forms. The concluding portion of the paper takes up the "S. K. C." alternator, the description and illustrations of which we here reproduce.

The rotary inductor is a cylindrical steel casting, with outwardly projecting, laminated pole pieces, A^1, at either end. The armature consists of two rings connected by wrought iron tie bars, *C*. The induced coils, *B*, are sunk below the surface grooves in the armature rings, and the stationary exciting coil, *D*, lies in the space between the pole pieces and the armature rings. The machine is very effectively ventilated by means of openings in the middle of the inductor under the exciting coil and the spaces between the tie bars. The exciting coil itself is protected from injury by a massive hollow ring of cast copper, inside of which it is wound.

Attention is called in the paper to the importance of keeping the flux constant in the inductor, so as to avoid hysteresis and eddy current losses therein. The only thing tending to disturb the inductor flux is the varying reluctance caused by a change in the relative position of the armature slots and the inductor poles. To keep this at a minimum is the chief reason for preferring a double wreath of induced coils to a single one. Mechanical interruption of both ends is necessary in either case, and it is wise to take advantage of it in distributing the induced coils. With the same amount of wire, the space variation of reluctance is much less when both air gaps are utilized than when only one is, and, at the same time, the regulation of the machine is better. As complete lamination of the body of the inductor is difficult, even a slight change of flux is to be sedulously avoided. Lamination of the pole pieces is necessary, even with constant flux, as the slots necessarily change its distribution.

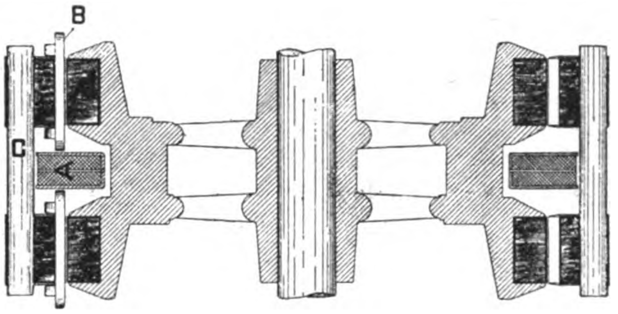

FIG. 2.—SECTION OF INDUCTOR ALTERNATOR.

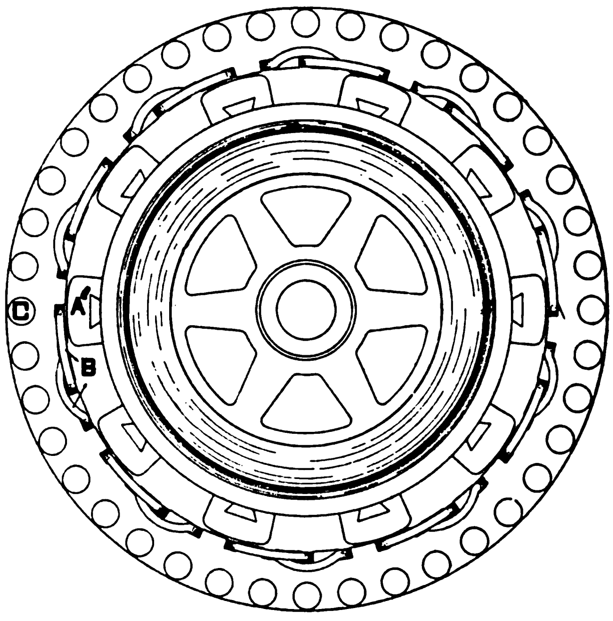

FIG. 1.—SIDE VIEW OF INDUCTOR ALTERNATOR.

But, even with the flux through the inductor constant, the difficulties are by no means surmounted. A large mass of iron in the armature is a necessity of the construction, and the losses in this way may be such as to make the machines practically inoperative. Only thorough lamination would put an end to the eddy losses, and thorough lamination is, for structural reasons, out of the question. Another solution is imposed.

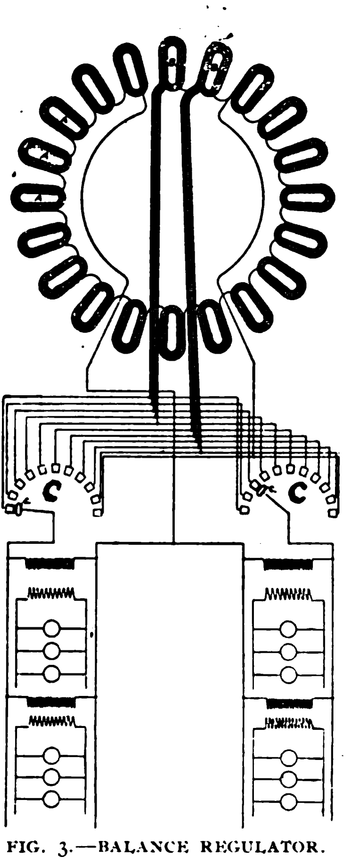

FIG. 3.—BALANCE REGULATOR.

Now, when the flux is constant in the inductor, it is obvious that in amount it must also be constant in the armature. It but shifts in position without altering in magnitude. But to give rise to the electromotive force in the induced coils, it is unnecessary that the shift should take place throughout the mass of the armature. It is necessary only that the shift should take place through the coils; that is, to the depth to which the coils are embedded. The problem is, therefore, to combine a steady flux in the center of the armature with a shifting flux in the armature faces; or, in other words, the distribution of the flux in the middle of the armature must be independent of the points in the face at which the flux enters. Stated in this way, an analogy with the conditions of electrical distribution in parallel is suggested and this points to the solution.

Consider for a moment the two laminated rings as electrical mains and the tie bars as translating devices. Then, if the two mains be of low, and the translating devices of high, resistance, the current through the translating devices will be substantially independent of the points of attachment of the feeders—the analogues of the inductor poles. Similarly, if the reluctance in the direction of the lamination be low in comparison with that in the direction of the tie bars, the magnetic flux in each bar will be constant, no matter what the position of the inductor poles. In this manner, the change of flux is confined to a small portion of the armature iron, which may be thoroughly laminated, and thus eddy current losses are suppressed and hysteresis losses reduced to a minimum. It thus becomes possible to use in the armature any quantity and form of iron demanded for structural reasons.

It will be noticed that the inductor poles are curved in a special manner. This is done to make the E. M. F. curve as nearly as possible a sine curve. Mr. Kelly added that as his firm is engaged in building machines for general service, and believes that the sine curve is the best for general distribution work, that form of wave is used.

The heavy copper bobbin surrounding the exciting coil, besides being a mechanical protection for the coil, is also of use in that it prevents the development of an excessive electromotive force in either exciting or induced coils, if the exciting circuit should be accidently broken. It resists very powerfully any sudden change of flux.

An important advantage of all stationary induced coil machines, and, of course, therefore, of inductors, is the possibility of regulating separate circuits or feeders with little or no auxiliary apparatus. Since it is possible to tap the armature coils at any point, any desired electromotive force between zero and the maximum may be obtained for one circuit without altering the excitation, and consequently, without interfering with the electromotive force of any other circuit. Circuits or feeders having different drops may thus be provided for. Fig. 3 shows one method of operation. The coils, *AA*, are the main inducing coils, giving the electromotive force necessary for all circuits or for the mains in a feeder and main system. *BB* are the auxiliary or regulating coils. The number of the regulating coils in circuit is controlled by the switches, *CC*. The diagram shows only two circuits; but, of course, any number may be branched on, each with its own regulating switch. This method is the simpler for the operation of only one or two machines. The adoption of this method secures the same flexibility and ease of control of the individual circuits as if a separate machine were used to feed each one, while, at the same time, there is a lower first cost and the greater economy of operation of large machines.

In the discussion of Mr. Kelly's paper, Dr. Bell referred to the sine wave controversy. As an explanation why a peaked current wave gives a better transformer efficiency, he stated that such a wave being composed of a fundamental and of higher harmonics, the higher frequency of the latter entails a greater efficiency in actual working than that of the fundamental sine wave; in other words, such an alternating current has an equivalent frequency in respect to the transmission of energy a little higher than its normal frequency. For running motors, however, the design of motor should correspond to the current wave of the line over which it will be operated.

ELECTROLYSIS.

Mr. Brophy read a paper in which he gave the history of various methods of underground distribution that had been tried, from the time that wires had first been placed underground in American cities down to the present. He referred to the very great damage done to the lead covering of underground wires by return street railway currents through electrolysis. He believes that the only real remedy is to cease using the earth and rail for the return circuit and employ metallic circuits, and considered it an injustice after a state legislature or city council has compelled a company for reasons of public safety to place its wires beneath the ground, that it should not protect that property after being placed there. The evil of electrolysis from electric railway currents can be reduced largely by extending cables into the danger district, which is usually within a radius of half a mile from the station. In cases, however, such as where a power station is built upon a rocky formation, such return cables will have to be extended to a greater distance.

Captain Brophy believes that in some cities it will be impossible to use lead covered cables in certain portions, and it seems to him that the manufacturers of cables will have to bestir themselves to find something for the better protection of wires placed underground than lead or other metal, unless street railways adopt an entirely different mode of construction.

Referring to the bonding of rails, Captain Brophy stated that while a bond may be perfectly safe to-day, six months hence it may, through electrolytic action, offer such resistance as to render it almost useless, and he added that he places no confidence in any rail bond on the market.

SINGLE PHASE, SELF STARTING, SYNCHRONOUS MOTORS.

F. H. Leonard, Jr., described a new type of single phase, self starting, synchronous motor which combines the principle of the ordinary alternating current, synchronous motor with that of the direct current motor or generator. The armature has two distinct windings; one of these is an ordinary distributed winding connected to a commutator similar to that of a direct current motor or dynamo, which winding in this motor is used for starting and afterwards for exciting the fields. The other winding is of the shuttle type so disposed as to produce distinct and regularly alternating poles in the armature, and which performs the regular work of rotating the motor armature, advancing it from one pole to the next with each alternation of the current. This shuttle winding is connected to collector rings at the other end of the armature.

An ordinary double throw switch on top of the motor is used in starting; there is no resistance or other complicated device, as the self inductance of the windings is sufficient to choke back any abnormal flow of current. In starting, the switch handle is depressed so that the wires leading the alternating current from the motor transformer are connected through the switch blades to contacts, from which the current is led, first to one of the commutator brushes, thence through the distributing armature windings and out through the opposite brushes to a closed wire winding on the field poles, and then back again to the switch contacts and binding posts, these connections being identical, it will be seen, with those of a direct-current series motor.

As soon as the current is turned on, the motor commences to rotate at a constantly accelerated speed until synchronism is reached, which is indicated by the lighting to a dull red of a lamp located on the switch. This is the signal for the reversal of the double throw switch, which then changes the connections so that the leads from the transformer are cut off from the commutator and connected to the collector rings and thereby with the armature shuttle winding; at the same instant the commutator brushes are connected to supply the field with direct current, the only office of the commutator after the motor is started and up to speed being to supply the small amount of direct current necessary to magnetize the field. In starting without load, the motors, according to size, etc., will run up to synchronous speed in from five to fifteen seconds and, when loaded, in from fifteen to thirty seconds.

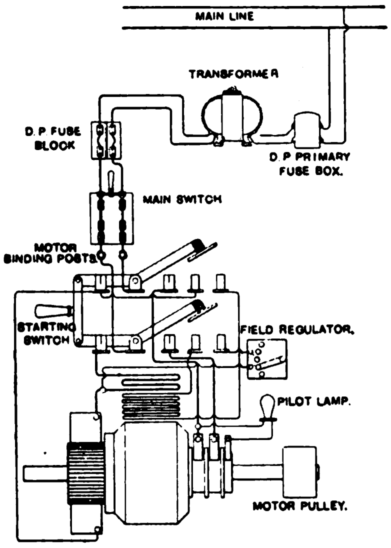

DIAGRAM OF CIRCUITS.

The direct current winding delivers a perfectly smooth current, which passes through a rheostat in the field winding by which the extent of field excitation is controlled. This rheostat is located in a recess in the base of the motor, the handle for its regulation being accessible through an oval opening at the commutator end pedestal. The motor starting switch and field rheostat are in one piece, making a simple and compact combination. These motors are suited to any frequency in general use, being wound for from 140 to 60 complete periods per second. They are wound for from one up to and including ten horse power, are for from 50 to 110 volts alternating secondaries, but larger sizes of motors are designed for higher potentials and even for direct connection to a primary circuit.

Mr. Leonard pointed out that these motors, though specially designed for single-phase circuits, will, of course, work quite as satisfactorily when connected to either two or three phase circuits, and possess the advantage in these latter cases of reducing inductive drop if their fields are kept over excited. The motor also answers the requirements of a good rotary transformer, lending itself very conveniently to charging storage batteries and electrolytic work, the alternating current entering the armature through the collector rings, and the continuous current being taken from the commutator brushes.

In the discussion of the paper by Mr. Leonard, Mr. Wagner asked whether the effect of the switching at the central station found necessary to properly divide the load on alternating current generators, would not cause the motor to fall out of step. Mr. Leonard replied that if a motor fully loaded had the current switched off, it would drop out of step and stop, but that most stations where the motor described had been used, the circuits upon which the motors were run were not switched except at hours when the motor was not in service, or the switching was done while the generators were in multiple, thus obviating the breaking of the circuit and the cutting off of the current. In reply to a question by Mr. Van Trump as to a difficulty experienced by him in operating such motors on account of their E. M. F. curve being different from that of the line, Mr. Leonard said that variations in curve made no difference. In reply to a question by Mr. Ferguson as to whether, in case a machine was started up on a light load and the operator did not throw the switch in time, the speed of the machine might not be so accelerated as to make it go to pieces, Mr. Leonard said that this might happen through carelessness, but not if instructions were followed.

THE EVOLUTION OF THE ARC LAMP.

Under the above title, L. H. Rogers read a paper tracing the arc light from its discovery by Sir Humphrey Davy to the present time. Mr. Rogers is of the opinion "That for the purpose for which it is intended to be used, the arc lamp, as we commonly know it, is mechanically and electrically the poorest designed and constructed piece of mechanism on earth"; he also thinks the statement cannot be denied, that not one single idea of great merit has been added to the arc lamp from the time of the original Brush lamp in 1875 down to 1895.

Discussing the improvement of the arc lamp, Mr. Rogers considers that the position in space of the arc itself should be stationary. He advocates that the upper carbon be made larger than the lower one, thereby obtaining the largest crater and the smallest obstruction beneath to the light. By using a ⅝ in. upper carbon and ½ in. lower carbon, $2.50 a lamp per year, he stated, may be saved. With the upper carbon fourteen inches long and the lower carbon twelve inches long, a lamp will burn from fourteen to sixteen hours, an equal stub will be left of each carbon and the arc will be kept practically in the same position during the entire run. Another advantage is that a five-eighths upper and one-half lower carbon held loosely at the clamps and guarded near the arc, will absolutely prevent the wedging or slipping by, whether the lamp be shunt or differential.

The carbon rod with its ring clutch is condemned. Mr. Rogers favors a short lamp, as the casing can be made of light cast iron in such shape as to avoid the necessity of a hood, the carbon lengths can be increased and the size of the carbons so proportioned that the upper one will produce the largest crater and the lower one offer the least obstruction to the light. If the upper carbon is hung on a chain suspended over a sheaf and the lower carbon is attached to the end of the chain with proper adjustment, several things may be accomplished; the chain can be made of equal length, inch for inch, with the upper carbon, so that as the latter feeds down when an inch of carbon has been consumed, the weight of an inch of chain has been added, and the regulating armature remains in the same plane between the pole pieces of the magnet as before. Thus there is no restriction on the weight of the carbon and any size most suitable can be used.

The double carbon arc lamp is condemned for a number of reasons, and the advantages pointed out of a single pair of carbons burning sixteen hours, and of a lamp with only a single arm of small cross section reaching down to sustain the globe holder. The shadow from this arm can be thrown directly against the pole or building, leaving absolutely unobstructed light for the street.

REPORT OF THE COMMITTEE ON DATA.

The Committee on Data submitted a report containing a tabulation of data received from eighty-two electric light stations. The average result from the eighty-one stations using coal as fuel is 108 watt hours produced per pound of coal, or seven pounds of coal per horse power hour, nearly. A report was received from a station using crude oil, which shows a production of 214 watt hours per pound of oil.

The following is a compilation from the reports giving the data of the several stations which appear to have made careful tests:

The average evaporation per pound of coal from all of the stations that sent such data was 7.09 lbs. of water per pound of coal. This figure refers to the actual coal used and not to evaporation from and at 212 degs.

Hours in run	Kilowatt-hours, one day.	Tons of coal per day. (2,000 lbs.)	Watt-hours per lb. coal.	Water evaporated pr lb., combustible from and at 212°	Pounds water per I. H. P.-hour.	Kind of coal.	Type of Engines.	Type of boilers.	Dynamos.
24	26,402.2	62.2	212	10.22	18	½ soft coal. ½ hard screenings.	triple exp. condensing.	water tube.	direct con'cted
24	5,053.2	14	180	....	36.9	½ hard coal. ½ pea and dust.	Corliss compound condensing.	1 water tube, 5 hor. tubular.	belted.
24	1,818.8	5.1	178	6.41	27.6	4-10 coke, 6-10 coal.	simple condensing.	hor. tubular.	belted.
24	4,270	13.3	161	....	42.2	½ hard coal, ½ pea and dust.	Corliss compound condensing.	1 water tube. 5 hor. tubular.	
24	5,402	21	129	....	30	Semi-bit.	simple and compound non-condensing.	vert. water tube. hor. tubular.	
13	2,103.8	8.4	125	8.73	26	ant. buckwheat.	simple non-condensing.	hor. tubular.	
14	477.4	2.7	88	11.13	37	semi-bit.	simple high speed non-condensing.	hor. tubular.	belted.

In conclusion, the report states that the economy secured in generating power for electric work does not compare favorably with the production of power for other purposes, and that this is also true after taking into consideration the variations in load due to electrical work. Referring to a recent statement of the economy obtained at the Chestnut Hill pumping station in Boston, where it has been found that an actual horse power in water lifted was produced by the consumption of 1.34 lbs. of coal, it is remarked that, assume that the efficiency of pumps compares favorably with the efficiency of electric generators and making no allowance for variation in load, one pound of anthracite coal, used with the same economy, in electrical work should produce 557 watt hours. As stated above, the average for all the electrical stations and for all kinds of coal is only 108 watt hours.

ACETYLENE GAS.

Louis A. Ferguson read a paper giving some figures on the cost of production of calcic carbide, and considering its commercial value as an illuminant. He estimated that the cost of production at Niagara cannot be less than $34.69 per ton or $37.69 per ton delivered at Philadelphia. The former figure represents the cost of manufacture to a large gas company operating in New York, Boston, Philadelphia or Chicago, having its carbide works at Niagara, and whose business it would be to produce acetylene gas from the carbide and distribute it to customers through existing mains. He states that the present average cost of illuminating gas in holders approximates thirty cents per thousand cubic feet, while the cost of acetylene gas in a holder with calcic carbide at $34.69 per ton would be equal to illuminating gas at thirty-seven cents per thousand cubic feet, making illumination furnished by the latter approximately twenty per cent higher than that of ordinary illuminating gas.

He pronounces a plan of distributing liquid acetylene in cylinders as entirely impracticable and uncommercial, there being insurmountable objections to such a method. Experiments, he affirms, have shown that though coal gas may be enriched by acetylene, water gas is not susceptible of enrichment by it; water gas, he added, is now used for illumination in nearly all the large cities, being treated with petroleum in order to increase its very low natural candle power.

In regard to the suggestion that the manufacture of calcic carbide may be carried on by central stations as a by-product, Mr. Ferguson replies that from direct knowledge as to the cost of operation in the larger central stations of this country, he can safely say that the average cost of fuel alone in stations having the most modern type of multiple expansion condensing plant, averages .3 cent per kilowatt hour or, approximately, $20 per horse power per year for continuous service, while the total cost of generation in the station would average over double that amount. In the average of the large central stations, the generating cost at the switchboard approximates one cent per k. w. hour, which is $65 per horse power per year, and in the smaller station using steam it is double that amount. With carbide at $40 per ton, the cost of twenty-five candle power hours would be one cent, which would be the cost of 160 c. p. hours of light from electrical energy supplied to incandescent lamps, or 575 c. p. hours if supplied to arc lamps.

From the deductions in his paper, Mr. Ferguson concludes that in the light of present knowledge and upon the basis of the estimated cost of calcic carbide, acetylene gas should not drive the incandescent or the arc lamp from the lighting field, and neither should it make such inroads on the electric lighting business as to materially affect the earnings of the electric central station lighting companies. After all, he says, acetylene is a gas and burns with a naked flame, while the present use of arc and incandescent lamps is not because of their cheapness, but because of their infinite superiority as illuminants over any gas flame yet developed.

INTERIOR CONDUITS.

In a paper entitled "Evolution of Interior Conduits from the Electrical Standpoint," Mr. Luther Stierenger reviewed the development of interior electrical wiring, and concludes that the best experience of the past fifteen years has demonstrated the following facts:

1. Indiscriminate wiring with staples is universally condemned.
2. Cleat wiring is admissible in exposed work where the circumstances admit, but not in concealed work.
3. Wires imbedded in plaster, depending on the insulation only for protection, are condemned.
4. Lead covered wires are also condemned, except where protected in a conduit.
5. Wires in mouldings do not afford mechanical or chemical protection, and are only admissible in surface work.
6. Wires carried in plaster and covered with split or zinc tubes to prevent injury by trowels, are condemned.
7. Glass or porcelain insulators can only be utilized in special cases of exposed work.
8. Paper tubes do not afford absolute mechanical and chemical protection.
9. Insulated tubes covered with a thin coating of brass or other metals, do not afford absolute mechanical and chemical protection, but, in exposed work, they are, to a certain extent, admissible.
10. Woven fabric conduit does not afford absolute chemical and mechanical protection.
11. Heavy insulating covering, integral with the insulation, offers no absolute protection against mechanical and chemical injury, and is analogous to rubber tubing for gas distribution installed throughout a building.

12. Concentric wiring is practiced in England with satisfactory results, but is not in use in the United States. It offers many possibilities in the direction of a solid and fixed system.

13. Paper lined iron or steel pipes, known as "Iron Armored Conduit," "Builders' Tube," "Armorite," "Clifton," and plain iron or steel pipe, are the only conduits that can afford absolute security against mechanical and chemical injury and assure permanence.

Mr. Stierenger added that there is another embryo system that may be developed, possessed of sufficiently desirable features to yet become a standard and a rival of the conduit for interior distribution. This consists of a solid or fixed system, in which the conductors are firmly fixed in position with the insulation in an injury-resisting metal tube or covering, which can be made of any length to suit all requirements.

The following opinion relating to plain iron tubing is quoted with approval: "the reason for a lining in the interior of iron pipe must be either mechanical or electrical; if it is simply mechanical, it is inexpensive. If the reason is electrical, is it not rather anomalous that, in a city like this, you can have one hundred miles of pipe in the street in which the insulated wires lie in a bare grounded tube, whereas the moment you go into a house you must not have it?"

Mr. Stierenger quotes Prof. S. P. Thompson who said: "What is wanted is a mode of running the wires and fixing the switches and other accessories, that they shall not only be electrictight, but shall be watertight, gastight, airtight, oiltight and rattight" and he adds that all of the above requirements, and more, are filled by a properly insulated conductor inclosed in an injury-resisting metal pipe.

A STANDARD INCANDESCENT LAMP SOCKET.

Alfred Swan submitted a communication on the question of a standard lamp socket, the adoption of which, he said, would have to await the adoption of a standard lamp base. He criticised the present forms of bases, and thought the most practical and satisfactory solution is a form of base or mount so inexpensive that when the lamp is destroyed the base may be allowed to go with it as in itself a thing of no value. In view of the fact that high tension lamps are in all probability to be the lamp of the future, the question of a safe socket acquires vast importance. Porcelain, he considers, will no doubt come largely into use for this purpose, which will greatly modify the conditions governing the selection of both a base and socket. As even a small saving in the cost of base amounts to a considerable sum in the aggregate, it is in this direction that economy should be most encouraged.

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Vacuum Tube Lighting.

Mr. D. McFarlan Moore, in a paper read before the American Institute of Electrical Engineers, Apr. 22, described the result of some of his work in vacuum tube lighting. In his system of lighting, Mr. Moore employs a make-and-break in a vacuum, one form of which is shown in Fig. 1. The apparatus consists of a spring rigidly supported from one end and having attached to its free end a disk of soft iron; a contact point rests against the spring at about its centre, the whole spring and contact being enclosed by a sealed glass tube from which the air is exhausted. External to the vacuum tube is an electromagnet, which, when excited, attracts the soft iron disk. In short, the apparatus is similar to that of an electric bell make-and-break, the contact points, however, being in a vacuum. Fig. 2 shows the connections with the source of current and with a lighting tube.

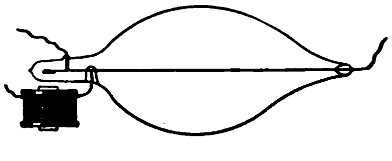

FIG. 1.—VACUUM MAKE-AND-BREAK.

In order to illustrate this method of vacuum lighting, twenty-seven tubes were placed in position in the Institute Hall, each 7 ft. 6 in. in length by 1¾ ins. in diameter, to which power was supplied by a 7½ k. w. dynamotor. It was stated, however, that owing to an accident to the motor rheostat, only about two horse power of the capacity was used. These tubes were lighted several times during the evening for a minute or less at a time. The amount of illumination from the entire number of tubes was estimated by several of the audience as equivalent to that given by four to five 16-candle power incandescent lamps. The circuit of the tubes contained, in addition to the make-and-break magnet shown in Figs. 1 and 2, a number of large inductance coils. The principle of the method by means of which the light is obtained does not appear to differ from that usually employed in the operation of Geissler tubes with an induction coil, the difference lying in the fact that in one case the contact points are in the open air and the other in a vacuum. An advantage follows from the latter disposition, however, owing to the quicker extinguishment of the spark at break, which results in a larger E. M. F. at the tubes than could be obtained with an ordinary induction coil of the dimensions of the vacuum break apparatus.

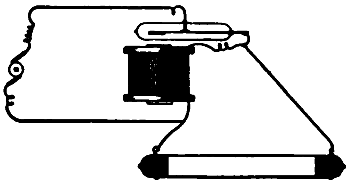

FIG. 2.—DIAGRAM OF CIRCUITS.

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Twenty Years' Progress in Telephony.[*]

BY S. G. M'MEEN.

Generally speaking, a multiple exchange switchboard is simply this: Each line enters the central office switchboard, and at intervals of about six feet, which is found to be about the maximum mechanical reach of any operator right and left, that line appears at a spring-jack. Three operators may be seated before the switchboard within this space of six feet. Tracing further the passage of such a line through a large switchboard, we find it reappearing at a spring-jack as many times as there are sections of a switchboard six feet in length. Each line is provided in a suitable manner with an annunciator as in the forms of switchboard having no such multiplication of spring-jacks. This annunciator is not multiplied in number, there being but one for each line. The annunciators are grouped together and a certain number (50 to 100), is attended by each operator.

It is to be borne in mind that the sole object of such an arrangement of circuits in a telephone central office is to place all the lines of such an exchange within easy reach for connection, of every operator, while giving to each of the necessary operators a limited number of lines from which to take orders and for which to make connections. In order that one operator receiving a call for a given line may not connect the calling subscriber with that line while it is in use for conversation, it is necessary to provide some means by which she may know whether or not the line called for is already in use or "busy." Many devices of great ingenuity have been produced for this purpose, but that which has been found most satisfactory is an arrangement of one form or another whereby the operator desiring such connection may simply touch the tip of the connecting plug, which she is about to insert into the spring-jack of a given line, to the metal of the spring-jack before so doing. If this line is engaged for conversation, this operator will hear in the telephone receiver, which she continually wears, a click, known in the language of the craft as a "busy test." In the absence of such "busy test" she will make the connection and call the subscriber in the usual manner.

Considering the matter of station equipment and central office apparatus as sufficiently described for the present, attention must be given to an equally vital portion of the telephone plant, viz., the line. When it is recalled that the only electrical circuits for transmission of any character, existent at the date of the first telephone exchange, were telegraphic, and that for such purposes single grounded iron wires were then exclusively used, it is not to be wondered at that just such circuits were adopted for telephonic service as well. For limited distances the availability of such circuits was in a large degree satisfactory. With the multiplication of subscribers' lines, however, it was soon found difficult to carry these single, open aerial wires in sightly and secure manner upon aerial supports, and to bring them conveniently in to central office. Recourse was then had to aerial cables containing a large number of conductors. With the existence of this method of circuit distribution came disturbances from "cross talk," this term being applied to induction interferences from various causes between narrowly separated circuits.

With the advent of the street railway, extraneous disturbances were greatly magnified, and in many cities the greater portion of the entire exchange rendered practically inoperative. When it is remembered that the earth itself largely forms a return for such street railway systems as are to-day in operation, and that wide differences of potential exist between the center and the outskirts of any town having such traffic conditions, it will be readily understood why the one system disturbs the other. As a means of escape from these evils without excessive expense in construction, recourse was had to common return wires. By this is meant a return circuit of low resistance for each general route of conductor distribution, to which the former ground wires of the various lines are attached after leaving the subscribers' instruments. At the central office these conductors are united together and substituted for the former actual earth connections. The entire plant is thus freed from ground connection at any point. The common return wire, however, has not been found a complete panacea for all telephonic evils, cross talk due to proximity of wires remaining unchanged. This character of disturbance is due almost wholly to the electrostatic capacity of the conductors, their mutual action upon each other electro-magnetically having little bearing upon the case. That is to say, if for a few hundred feet of cable length the capacity of the two conductors be mutually low and their conductivities high, there will be mutually little disturbance. If, however, the capacities be large, the conductivities remaining permanent, the mutual disturbances may be so great as to prohibit an undisturbed use of both at the same time for conversation. The same difficulty has been experienced upon long, open, aerial wires, the additional length making up for the diminished disturbance due to greater separation.

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[*] Paper read before the Chicago Electrical Association, Mar. 6, 1896. Concluded from page 98 of *Electrical Industries*.

In exchange circuits exclusively, by reason of their being limited to but a few miles, noises due to atmospheric electricity are not marked, whether those circuits be grounded or otherwise. In interurban communication, however, requiring lines of many miles in length, electrostatic disturbances from atmospheric causes are very pronounced. The character of these disturbances is very peculiar and has served not only to seriously disturb attempted conversation over long distances, but has formed a topic for study and investigation of no small importance. It is quite likely that future investigations of atmospheric conditions for purely scientific purposes may be greatly aided by these phenomena, but they have so far been a pronounced cause of unsatisfactory telephonic communication.

We see, therefore, that in the province of telephone line interferences there are three necessities demanding cure: First, mutual conflict between telephone circuits; second, mutual conflict between telephone and other electrical circuits; and, third, disturbances from natural causes. There are in existence devices intended for application to the line without changing its form, which have been the result of great thought and ingenuity, and have, in greater or less measure, accomplished their object. In no single instance, however, has a result of high order been achieved, and none except at a loss of value in transmission.

Over ten years ago, however, attention was turned to the improvement of the condition of the line itself, and the result, generally speaking, has been the production of a method of construction providing a high grade telephonic circuit. In brief, this result was arrived at by providing a metallic circuit of two wires with no earth connection. It is essential for the construction of such a circuit to provide the two conductors with exactly the same resistance, capacity and insulation, and with the nearest approach to the same physical condition for each wire. Placing the wires very close together in such a circuit assists in eliminating disturbances from outside causes, but increases the mutual capacity from wire to wire. In practice, it is found that two wires of any length, both of the same material and size, will produce a circuit almost wholly free from atmospheric disturbances and those due to reasonable distant circuits carrying heavy currents. Two such circuits, however, unless an additional precaution be taken, will seriously mutually interfere. A system of mutual transposition of the two wires of a circuit as to mechanical position has therefore been devised, having for its purpose the elimination of this metal interference.

It is possible, by means of these precautions, to erect upon a given structure any desired number of separate and distinct metallic circuits entirely free from mutual and external disturbances of any character. It is possible over such circuits to carry on as satisfactory conversation as can be held between two individuals, face to face, under the most advantageous conditions. It is possible by means of a reasonably simple system of auxiliary apparatus to carry on one circuit in addition to an ordinary speech conversation, two separate and distinct conversations by Morse telegraphy at the same time, making simultaneous telegraphy and telephony over a single circuit entirely feasible commercially.

There is not the slightest reason to doubt that conversation between San Francisco and Boston will soon be accomplished.

Considering for a moment the physical character, from an engineering standpoint, of the New York-Chicago circuit, it may be stated that the supports are generally thirty-five feet in height, the conductors, of hard-drawn copper No. 8 B. W. G. .165 in. diameter, having a capacity of a little over .015 microfarad per mile each to earth. The capacity from wire to wire, which is the important characteristic in considering speech carrying power, is about sixty per cent of the capacity of one wire to earth, or .009 microfarad per mile of circuit. Roughly speaking, the resistance per mile of wire of this gauge is two ohms, making the resistance of the New York-Chicago circuit 4000 ohms, and the capacity from wire to wire nine microfarads.

The range of frequencies of the currents used in speech transmission correspond, of course, to the frequencies of the actual vocal waves, varying between 120 and 600 per second. With these frequencies and the functions above mentioned, five parts in 1000, or one-half of one per cent of the original currents become effective at the receiving end. The amount, however, is sufficient to produce a volume of tone not noticeably less than that received over much shorter lengths of line. So that in this branch of the electrical transmission the variables take somewhat unusual values.

The Electric Light Association of Pennsylvania. The annual meeting of the Electric Light Association of Pennsylvania was held at Harrisburg, Apr. 9, 1896, with an attendance the largest in the history of the Association, much interest in its work and plans being shown by those present and in letters received from others. The desires of the different companies for data regarding the operation of other plants to aid them in making comparisons with their own plant were recognized, and uniform blanks were adopted for the compilation of such information, the data to be at the disposal of members of the Association; in all other respects to be considered as confidential. The question of future legislation was referred to a committee, to be appointed by the president; the president to be chairman of such committee and to have power to select assistance as he may deem advisable, with instructions to draft such bills as may be thought necessary for the proper protection of lighting interests throughout the state; such bills, when drafted, to be reported and passed on by the Association at a special meeting to be called for the purpose. The following officers were unanimously elected to serve one year: president, Robt. E. Wright, of Allentown; vice-president, P. B. Shaw, of Williamsport; treasurer, R. D. McGonnigle, of Pittsburgh; secretary, John R. Wheeler, of Pittsburgh; executive board, A. J. DeCamp, of Philadelphia; Henry Clay, of Philadelphia; John A. Rigg, of Reading; C. A. Wolle, of Bethlehem, and John S. Rilling, of Erie.

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Annual Report of the General Electric Company. The fourth annual report of the General Electric Company shows that the gross earnings for the past year amounted to $13,315,667, upon which there was a gross profit of $1,555,810.04. The sales during 1895 were less than ten per cent greater than the previous year, though the output increased more than thirty per cent, due to decreased prices received for goods. The gross earnings were $52,056 greater than in 1894. The amount of profits available after paying interest on debentures was $1,388,967, an increase of $41,803 over the previous year. Of this $511,321.97 were applied to writing off patents, franchises, factory plants and other real estate, leaving $877,645 to reduce the deficit of previous years, which still remains $13,917,071.48 on gross liabilities of $43,963,069.43. Among the assets, patents and franchises are carried at $8,000,000, factory plants at $3,468,002, stocks and bonds at $5,479,332.23, notes and bills receivable at $6,584,123.30, cash at $961,386.38, and work in progress at $4,219,883.63. The liabilities are $30,460,000 in common stock, $4,252,000 in preferred stock, $8,750,000 in bonds, and $501,069.43 in accrued interest on bonds and bills payable. The sales department reports 104,000 separate orders during the past year from over 10,000 customers, or an average of about 350 per day. The manufacturing department reports that the capacity of the company's various plants was increased at least twenty-five per cent during last year. The output was 380,000 k. w. (509,000 h. p.), and no less than 60,000 h. p. of apparatus were supplied or ordered for water power electrical transmission plants.

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SALUTATORY.

Nowhere does the saying, "The proof of the pudding lies in the eating" apply with greater force than in the judgment of a new aspirant in the field of journalism. Examples are so frequent of journals instituted to supply "widely felt needs" that subsequently are found not to exist; of publications to be conducted on new plans unhappily soon demonstrated to be mere theories; of periodicals designed to serve classes neglected in the past, but who ungratefully refuse to succumb to the blandishments of the new comer. In short, journalistic realization too often is so widely short of promise, that editorial salutatories are apt to meet with but languid interest from the public, or be regarded as somewhat akin to recitals of the sanguine expectations of youth on the eve of entering the work-a-day world. In deference, however, to time honored custom we will here briefly outline the plan and purpose of this journal as issued in its present form.

The purpose of the AMERICAN ELECTRICIAN will be primarily to supply practical information for practical men, and also to put before electrical readers in general, information regarding the latest electrical advances in such form and in language so simple that all may understand without necessarily having previous knowledge on the subject treated. To this end no mathematics will be employed, and purely scientific forms of expressions will be avoided. This, it should be added, does not mean, as the example of some practical journals might imply, that all sorts of odds and ends will be printed whose sole qualification is that they are easily read, or that our columns will be delivered over to the verbose class of writing which consists merely in the stringing together of platitudes, or in the lengthy discussion of points whose bearing could not be mistaken. On the contrary, all matter admitted to our pages will be as carefully and as conscientiously selected or prepared as if it were to come under the eyes of the most severely critical audience; and, though simply expressed and practical in its bearing, it will nevertheless be scientifically correct. The articles in the several practical departments will be prepared, not by those having merely the knack of writing on practical subjects with which they have really but slight acquaintance, but by men of thorough practical experience, whose technical opinions carry weight in their daily life.

Among the special features, aside from the purely practical departments referred to in detail later, will be the treatment of alternating currents, of new developments in electrical science, and of subjects of timely importance. The subject of alternating currents is yearly becoming of more importance, and in these pages that branch will be given a prominence in accordance with its increasing claims on the attention of practical men. Heretofore the literature relating to alternating currents has been almost exclusively highly mathematical or purely scientific in its character, but, as we hope may be demonstrated in our columns, there is no real reason why the subject should not be brought within easy reach of practical men, even in its more complicated aspects. The consideration as they occur, of new developments in electrical science and the discussion of other current subjects of interest, in the form of articles from authoritative sources, will, we believe, be features much appreciated. Such articles, which will also be simply written, should enable our readers to gauge the probable effect of new discoveries on current practice, as well as place them in the van of electrical progress in general. Every number will also contain several articles of no less interest to the general than to the technical reader.

The plan of treatment in the lessons on practical electricity will differ somewhat from the usual one followed. Little or no attention will be paid to such subjects as static electricity, and text book illustrations will be conspicuous by their absence. The principles of alternating currents will be so developed in connection with those of continuous currents, as to impart a knowledge of both at the same time, and thus avoid creating an impression that the latter is so widely separated from, and so much more mysterious than, the other. The department of queries will receive careful attention, and readers are requested not to hesitate to avail themselves of its advantages. The catechism, which has met with such wide appreciation in the past, will be continued, and in the department of "New Appliances" the articles will be confined to clear and concise descriptions of the devices or apparatus illustrated without the usual accompaniment of extraneous matter.

The distinctively practical portion of the journal will comprise a number of subjects. Articles on the operation of the dynamos in lighting, railway and isolated plants, the care and management of boilers and engines, the repair of apparatus, the detection and remedy of faults, etc., will form one of the most important features, and enter into much detail. A series of articles on house wiring will form an important contribution to a branch of electrical work that has received but little attention in print. Practical hints, kinks and expedients will form the subject of articles or notes; contributions to this department will be particularly welcomed from our readers, as with their aid it can be made one of great usefulness. As the steam engine is of prime importance in the general tion of electrical energy, much attention will be paid to that subject; in this number a series of articles is begun which will, in turn, take up the various points necessary for an intelligent understanding of its principles. While the several practical departments will be conducted continuously from month to month, the endeavor will be to have each installment complete, in a sense, in itself, though connected to the preceding and succeeding one in logical order, and having a definite part in a general plan of development of the subject treated.

Finally, as to limitation of scope. Believing that the purely scientific branches of electricity and the more strictly technical side of electrical applications are already well cared for by several excellent journals now in the field, and, moreover, that the weekly electrical periodicals also thoroughly cover current news matters, the scope of the AMERICAN ELECTRICIAN will not extend in any of these directions. Consequently, we believe we may be congratulated upon occupying the enviable position of having few, if any, interests to clash with those of our esteemed contemporaries, with whom it will always be our desire to maintain the most friendly relations.

The National Electrical Exhibition.

The industrial shows held in New York City usually merely appeal to a local audience, but the National Electrical Exhibition opened in that city May 4, does not belie its name. Its close relations with the National Electric Light Association during the annual convention of that body, as well as the extent and broad scope of the exhibits installed, make it representative of the electrical industry in a national sense. While some familiar names are missed from the list of firms exhibiting, they are rather those of supply houses from distant cities than manufacturing firms.

While the very complete and well arranged trade exhibits are well worth making a trip half across the continent to see, greatest interest centers in the remarkable historical collections that have been here brought together and admirably classified, and in the superb Röntgen working exhibit of Edison and that of the "Practical Electrical Engineering Laboratory." Even were the exhibition a local show, all connected with electrical science and its practical applications would be gratified with the brilliant success it has thus far achieved. The executive officers of the exhibition, President H. J. Smith, Secretary Geo. F. Porter and General Manager C. E. Stump, as well as the other gentlemen connected with the enterprise, are to be congratulated upon a success reflecting credit both upon themselves and the electrical profession in general.

The National Electric Light Convention.

The nineteenth annual convention of the National Electric Light Association, though its sessions were not so well attended as usual, was nevertheless a successful one. The papers, of which we publish abstracts elsewhere, were well up to the standard, particularly those read by Messrs. Kelly, Emmet and Rodgers. The attention given to alternating currents, both in papers and discussion, was greater than at any previous convention, thus emphasizing the rapidly growing importance of this branch.

Two actions of the convention give promise of valuable results in the future—the appointment of a committee to co-operate with the American Institute of Electrical Engineers in the determination of a standard of light, and the authorization of the employment of an expert to report upon the cost of operation of central stations. The present condition with respect to determining candle power is extremely unsatisfactory, and it is high time that something is done to place this very important matter on a satisfactory basis. We believe, however, that the question is a broader one than merely the determination of a standard of light and arranging for the standardization of secondaries. To obtain comparable results from measurements, the programme should also include the adoption of a specific form of photometer and of a standard and rigorous code of rules regulating its use.

The adoption of the recommendation of Mr. Swetland that an expert be employed to report upon the actual cost of operation in selected stations of different types, was perhaps the most important action taken by the convention. Notwithstanding the arduous and conscientious labors of the Committee on Data, its reports have had little value on account of the glaring discrepancies in the data furnished. This naturally follows from the complex nature of the case and the various constructions applied by different managers in estimating cost of operation, which determination, in fact, is one almost necessarily calling for expert knowledge.

Polyphased Currents.

From many inquiries received it is evident that a wide misapprehension exists as to the nature of polyphased currents. In a letter before us, for instance, a correspondent asks for an explanation of the "flow of multiple currents in a wire," which phenomenon he frankly confesses is beyond his comprehension—and beyond that of any one else, it may be added. The prevailing misapprehension on this subject is doubtless almost entirely due to the loose way in which those who know better speak of polyphased currents in the singular, and in their misapplication of the word "phase." The expression, "a two-phase current," and references to a part of a polyphased circuit as "one of its phases," are constantly employed, to the very natural mystification of the uninitiated.

Polyphased currents are two or more separate and distinct currents not differing in any way from the current derived from an ordinary "single phase" alternator. Their peculiarity lies, not in the nature of the currents themselves, but in the fact that they have different strengths at a given instant of time. In the two phased system, for instance, when one of the currents is at zero value, the other has its maximum value, or the currents are displaced *in phase*, whence the expression, two-phased. If two identical simple alternators have their armature shafts coupled in such a manner, that when a given armature coil on one is directly under a field pole, the corresponding coil on the other is midway between two poles of its field, the two currents generated will differ in phase by a half-alternation, and will be two phased currents; similarly, three phased currents could be generated by coupling the armatures of three simple alternators so that the corresponding coils on each are equally "staggered" with respect to each other. In point of fact, the above would be the ideal way of generating two and three phased currents. When the two windings, in the case of the former, or the three windings, in the case of the latter, are combined on a single armature with a single field, compounding for differences in load cannot be applied unless the several circuits are equally loaded, since the proper amount of compounding for one circuit might be too great for the other. The two currents of the two phased system have usually separate circuits, either of which is therefore a "single phase" circuit in itself. When three wires are used, the third wire merely corresponds to the common return of a continuous current circuit. In the three phased system it happens that the relative variation of the currents is such, that each wire alternately acts as a "return" for the other two, so that there are three circuits with but three wires.

It is only at the receiving apparatus that the valuable properties of polyphased currents are developed. In a four pole, two phased motor, for instance, one pair of opposite poles supplied with one of the two currents has its maximum strength when the other pair, supplied with the other current, has no polarity. On the other hand, the latter has then the greatest inducing power on the closed coil armature and the former the least. The consequence is that the second pair acts as the primary of a transformer, inducing in the closed coils of the armature a strong current; this current in passing under the first pair of poles develops a strong turning moment, exactly as in the case of a continuous current motor. In other words, while one-half of the field of a two phased motor is acting as part of a transformer, of which the armature is the secondary, the other half of the field is acting on the armature current, thereby producing motion as in a continuous current motor. The action of a multipolar two phased motor, or of a three phased motor may be similarly explained,

A Röntgen Ray Outfit—I.

THE INDUCTION COIL.

The induction coil whose construction is here described, is capable of giving a three-inch spark when energized from six or seven one quart bichromate cells or their equivalent, and is of sufficient capacity for experiments with Röntgen rays. The general principles of induction coils will not be considered, this article being confined to constructional dimensions, precautions and methods alone.

It will pay the person who attempts to make this coil, to go to relatively considerable trouble and expense in making the secondary or fine wire portion, for if this is well made, the working of the coil is assured. To this end, secure a hard rubber tube twelve inches long. Be sure the tube is of rubber, for there are many inferior substances that are used in making some hard rubber tubes (?) employed in electric construction. The tube should be 1¾ ins. in diameter; 1/16 in. is a good thickness, and the tube should, if possible, be reamed out to this dimension.

Provide six pieces of hard rubber each six inches square as follows: Two of one-half inch thickness and four of one-quarter inch thickness, the latter being used to separate the five sections into which the secondary coil will be divided. Drill a hole in the center of each so that the hard rubber tube will snugly fit therein. Polish the edges of these pieces and the support for the secondary coil is complete.

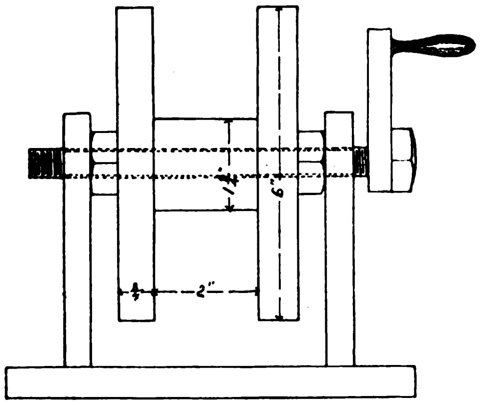

FIG. 1.

Prepare a clamp spool as follows (see Fig. 1.): Upon a bolt with a long threaded portion mount a two inch cube of wood, by boring a hole through the middle of two opposite faces and jamming it upon the bolt with two nuts. Center the bolt and in a wood lathe turn down the cube to an inch and three-quarter cylinder. It may be necessary to true up the sides, and if the hole can not be readily bored exactly straight, it would be well to allow some stock for this purpose so that the finished length of the cylinder will be two inches. Two pieces of board should now be mounted in with the cylinder, and turned up to two six-inch disks, as shown in Fig. 1. The clamp spool is now complete and ready to receive the wire.

The wire for the secondary coil should be No. 36 B & S gauge, and single white-cotton covered. Colored wire is to be avoided. A little over six pounds will be needed. Coils have been frequently made with the very expensive double silk covered wires, but the advantage gained is almost negligible. If proper precautions are taken, there will be no difficulty in producing a coil with the cotton covered wire fully as efficient as if it were wound with silk. As the ratio of the costs of these two wires is about four to one, it will pay to use the cheaper wire and take more pains in winding.

To begin with, wind a white strip of two-inch paper several times around the spool and start the winding upon this paper. The paper should be of six thicknesses for the end bobbins, four layers thick for the next bobbin and two layers thick for the middle bobbin. In winding these coils there is nothing more annoying than to have an end break off close to the bobbin, for it is not always easy to recover it. To provide against this contingency always make the terminals of a delicate wire consist of several wires twisted together.

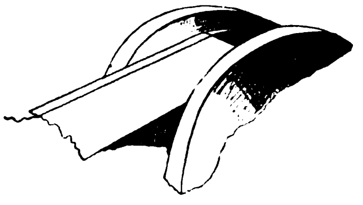

FIG. 2.

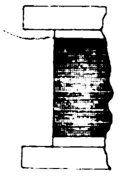

FIG. 3.

The apparatus for winding consists simply of two wooden bearings, in which the bolt supporting the clamp spool is turned by means of a hand crank at one end. This is preferable to any lathe, as the speed is under perfect control, a necessity with delicate wire.

Begin to wind at a distance of at least ¼ in. from the edge of the paper, and stop the layer at a similar distance from the other side. (See Fig. 3.) This is a point where many amateurs fail. In their eagerness to get on all the wire that is possible, they wind clear across, taking no heed of the fact that the liability of the discharge to jump from layer to layer is very great. By winding all the layers as directed, the discharge will either have to break down the insulation between layers, or travel ½ in. around, and both of these contingencies are improbable. The material between the layers is ordinary white paper. Paper without sizing is preferable, and should be cut into strips two inches wide and sufficient length to go at least twice around the coil, since the strips will increase in length as the winding progresses. They should be wound into position as shown in Fig. 2. Watch the wire for kinks and breaks as it goes on, and stop and examine every suspicious place. All joints should be soldered.

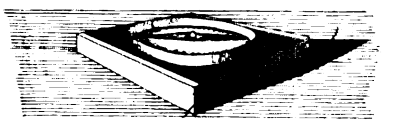

FIG. 4.

As the winding proceeds the wire should be tested for continuity at the completion of every layer. The inner end of the coil should be connected to the bolt on the clamp spool and by means of a spring clip pressing against this bolt contact may be made therewith. A battery in series with a high resistance galvanoscope should be connected from this clip to the fine wire when it is desired to test. The insulation of the wire may be scraped a little at the end of each layer for this purpose. The continuity of the wire will be evidenced by the throw of the galvanoscope. A good galvanoscope for this purpose may be made by winding about a one inch square piece of inch board a few ounces of No. 36 B. & S. wire, and placing a pocket compass upon the board so prepared, arranging the two so that the needle of the compass is normally parallel to the wire. (See Fig. 4.) Of course, as the winding proceeds the throw of the galvanoscope becomes less and less owing to the increased resistance of the coil, but the absence of any throw indicates a break in the wire. Detected thus early, the fault may be easily found and remedied.

In winding an induction coil of this kind, a loose bobbin is preferable to a tight one, although in all other electrical windings the reverse is the case. This is because when the finished bobbin is boiled in paraffine wax, the wax will thus be able to readily reach the inmost parts of the bobbin. The wax is what is relied on for insulation, the cotton on the wire and the unsized paper acting simply as a body to support the paraffine about the wire. When saturated with paraffine, cotton fairly rivals silk as an insulator.

The coils should be wound exactly alike, and care taken that the terminals come on opposite sides of the bobbin. This will prove of great convenience in subsequent connection. Each coil should be wound to a diameter of five inches.

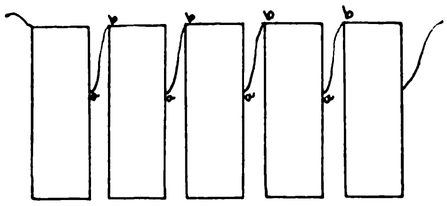

FIG. 5.

As has been just stated, the coils are to be boiled in paraffine wax. To do this, melt the paraffine in a pressed tin pan. Should you use one with a soldered bottom you might have cause to regret your choice. Heat the paraffine till it almost boils and lay the coil in the pan on its side. There should be enough paraffine to completely submerge the coil. Presently you will notice bubbles emerging from between the layers of wire on the upper side of the coil. These are, of course, driven out before the rising paraffine, and their exit should be facilitated as much as possible by jarring the coil. After the coil has become thoroughly saturated on one side, reverse it and allow it to remain for a while on the other side, in order to release any air between the layers that may have caught in pockets in the structure of the coil. The bobbin should remain in the hot paraffine at least one hour.

When ready to remove the coil from the wax, take the pan from the source of heat and allow it to cool till the wax has attained the consistency of mush. The bobbin may then be removed, and should be pressed flatwise between glass plates by means of a weight. This method produces a coil that is solid wire, paper and paraffine. If the bobbin were withdrawn from the paraffine when the latter was nearly at the boiling point, it would largely drain off and the interstices of the coil would be filled with undesirable air spaces.

Having prepared all the five coils, they are ready to assemble on their mounting, and this should be done at once. Cement the end of the long hard rubber tube into one of the ½ in. thick squares, and slip on one of the coils, having the outside end first. Drill one of the ¼ in. partition squares so that the inside end of the coil already on the tube can be conveniently reeved through, and slip on the next coil, inside end first. Connect the inside ends of the two coils together by a soldered joint, and slip on the next ¼ in. square. The outside ends of the next two coils are connected, and so proceed. The advantage of this method of winding and connecting will at once be apparent. If the coils had all been slipped on in the same order, they would have been connected as in Fig. 5. The connecting wire, *ab*, from the interior of one coil to the exterior of another passes within ¼ in. of layers which in air could discharge a spark to it at least ⅜ in. long. This would severely strain, and probably break down, the insulation. At the end connection of the coils, when built as directed, there is a similar difficulty which could have been avoided by using one more section. However the more sections, the greater the difficulty in winding them, and the less wire there can be put on because of the ¼ in. margin that it is advisable to employ and of the extra ¼ in. partition. Moreover, in this case the terminal can be safely brought out with a little care, as there is no adjacent bobbin to avoid. To do this, drill a hole through the edge of the two inch end piece as shown in Fig. 7, and as near the outer surface as possible. Through this hole reeve a flexible connector formed of several wires and thoroughly soaked in hot paraffine. This connector, of course, is joined to the inner end of the last coil.

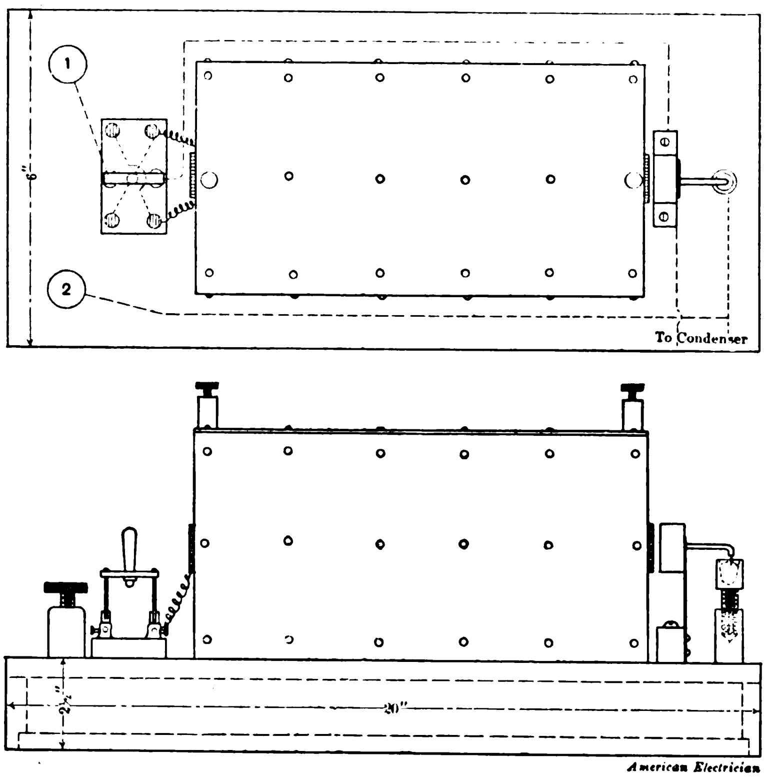

FIG. 6.

The outer hard rubber square is now to be securely cemented on and all the squares lined up. A base should now be constructed as shown in Fig. 6, and the coil securely screwed in place as indicated. The base may be of any nice looking wood that the maker may fancy.

Having screwed the coil in place, provide two pieces of hard rubber 1/16 in. thick and 6 ins. × 12 ins. in lateral dimensions. Screw these to the sides of the dividing and end squares, thus making a rectangular box with five compartments, in each of which is a bobbin. Fill each of these compartments with boiling paraffine and close the top of the box with a piece of 6⅛ in. × 12 in. hard rubber screwed into position. If round head brass screws accurately spaced are used, the work will appear very tasteful; and if the other directions have been carefully followed the coil will have an insulation which it will be almost impossible to break down. Two small binding posts should be screwed centrally on the top of the end pieces, and with the proper connections made to the two terminals the most difficult part of the coil is complete. We have now to take up the primary coil and remaining details.

In designing secondaries for induction coils maxima are aimed at. General proportions, known to be good through calculation or otherwise, are selected and the secondary is then wound with the finest wire and the greatest number of turns practicable. The object of the fine wire is to enable the large number of turns to be put on in small compass. Fineness of wire in itself is rather a disadvantage than otherwise, owing to its high resistance, but in this case the secondary voltage will be so great and the current forced through so small that the internal resistance cuts no figure. The secondary coil surrounds a core in which there is a rapidly varying magnetic flux due to the primary coil. One turn of the secondary surrounding this is nearly as efficient as another in producing voltage, the difference being in favor of the inner turns.

In designing the primary coil, little heed need usually be paid to heating effects, as the current ordinarily is on during but short periods at a time. Were it not for this fact it would require to be carefully designed and ventilated. It is necessary, however, to take account, in choosing the size of wire, of the source of power to be employed in energizing the primary coil. The energizing power of the primary coil is directly in proportion to its volume, and whatever voltage used a wire can be found to work with it successfully.

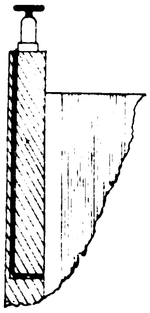

FIG. 7.

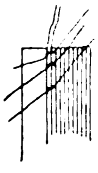

FIG. 8.

We have purposely made the secondary so that the primary is readily removable and two primaries will now be designed, one for battery currents and another suitable for connection to a 110-volt lighting service. Either may be substituted at will, an advantage readily apparent. With batteries, the size of the primary wire may have quite a wide range as the batteries can usually be grouped to suit, but with dynamo currents one and only one size of wire is most suitable.

To provide mounts for the primary coils, secure a hard rubber or, better, a pressed fibre tube, 1¼ ins. in external diameter and as thin as possible. If neither of these materials is available, an insulating tube may be made of thin paper wound around a stick and secured into shape with glue. Soap the layer next the stick to facilitate removal. The tube should be 12 ins. long and on either end should be mounted a circular wooden or hard rubber collar, ½ in. thick. The external diameter of this collar should be such that it will slip into the secondary spool without binding.

Drill a small hole in one of the collars near the tube, run the primary wire through this hole and proceed to wind it on. Double cotton covered wire is to be used. The size of wire suitable for use with batteries is No. 16 B. & S. About 1¾ lbs. will be required and it should be wound two layers deep clear across the spool. No insulating layers will be needed between wires, but the finished spool may be soaked in paraffine to exclude moisture.

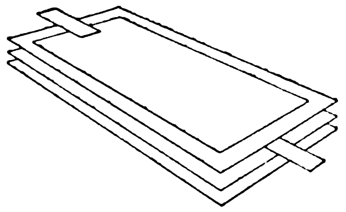

FIG. 9.

An annoying feature of coils wound with coarse wire is their tendency to immediately unwind the moment that the outer end is released. To prevent this, wind in a few strands of stout linen thread as shown in Fig. 8. When the last turn is in place, the thread may be pulled about it and thus secure it in place.

For the coil for a 110-volt current, such as may be obtained from an incandescent lighting circuit, No. 24 B. & S. wire should be used. About 1¾ lbs. will be necessary and six layers should be wound on with thin paper between them. The whole bobbin should then be soaked in paraffine. This primary coil requires a special arrangement for breaking circuit.

The brass work of the coil comes next. Binding posts it will be necessary to buy. Four will be necessary; of these, two small ones, as previously indicated, are for the secondary terminals and to be mounted on the end disks or squares of the coil. The other two posts form the battery terminal and are shown at 1 and 2 in Fig. 6.

It is convenient to provide all induction coils with a reversing switch, although this is not absolutely necessary. By means of it the primary current can be made, broken, and sent in either direction through the primary coil. This reversing switch may be conveniently made by procuring a double pole, double throw "baby" knife switch, and arranging as in Fig. 6. The connections are shown in the plan drawing. Of course, any double pole, double throw switch that is small enough to be convenient will answer.

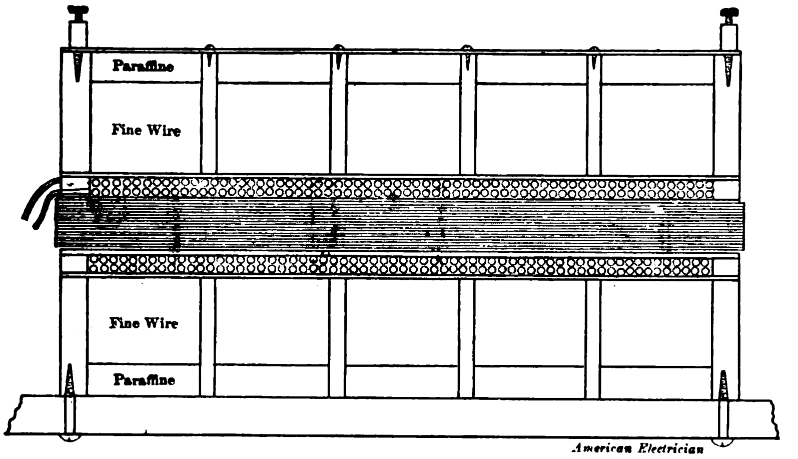

FIG. 10.

The circuit interrupter or rheotome is one of the most important parts of the whole apparatus. If we could make this part theoretically perfect, the fine secondary coil that we have taken so much pains to procure would be superfluous. If our interrupter would break circuit *instantly*, the electromotive force at the primary terminals, as well as the secondary terminals, would be infinite whatever their number of turns. Unfortunately, this abrupt break cannot be accomplished, owing to what is called the self-inductance of the primary coil. This reaction, for such it is, tends to force the current across the breaking points of the interrupter and actually succeeds in doing so for an appreciable length of time. This is evidenced by a brilliant spark at the points of breaking, and many have been the attempts to eliminate this spark. This tendency to spark and prolong the break increases with the *square* of the number of primary turns. Hence the longest secondary sparks, which are indicative of the highest electromotive force, are obtained with a coarse primary winding of few turns and a proportionately heavier current, provided all other things are equal. For this reason also, the second primary coil described for use with high voltages requires a special interrupter, which is rather complicated, and will be accorded a special discussion in another article.

It follows that the interrupter for the coarse coil should be made with special care. Referring to Fig. 6, a flat spring of steel or spring brass is mounted on a brass base block and carries a little cylindrical hammer suitably arranged to beat against the core of fine iron wires with which the tube on which the primary coil is wound, should be filled. A right angled extension of aluminum wire dips into a little cup of mercury as shown; this cup is of cast iron and is threaded at its base. By simply turning the cup in its socket it may be raised or lowered as may be required. The little button of mercury at the top of the cup is covered with a thin layer of very light paraffine oil, which frequently requires to be renewed on account of carbonizing. The aluminum wire, which is tipped with platinum, is sufficiently stiff to have no vibration period of its own, and therefore moves in step with the hammer. To put on the platinum tip is a work of some difficulty. The joint cannot be soldered, and still good contact is required. The writer has found that a driving fit of the platinum wire into a minute hole drilled in the end of the aluminum wire gives excellent results.

A small condenser in shunt with the interrupter materially reduces the primary spark at make-and-break by providing a by-pass through which the primary coil may discharge. A suitable condenser for this coil is made as follows: Provide 150 sheets of tinfoil 9 ins. × 7 ins. and an equal number of sheets of unruled white writing paper one inch larger in lateral dimensions. Arrange the sheets of tinfoil alternately with the paper, being sure that the tinfoil sheets are squarely centered on the sheets of paper, which should be thorougly soaked in paraffine. Connect the alternate sheets of tinfoil together by a narrow strip of the same material. Bring all these strips up to the top sheet as shown in Fig. 9. Prepare two boards of thin wood of the same lateral dimensions as the paper, and place the prepared sheets between them. Two short pieces of very thin brass may be placed on the tops of the pile of tinfoil strips as shown, and will form good terminals on which to solder wires. The whole may be strapped together with adhesive tape. The condenser may be conveniently installed in the base of the coil. It will be found convenient to provide screw cups on the two parts of the interrupter for the ready attachment of other condensers, and also for the convenient use of the coil condenser for other purposes. A small single pole switch may be added to open the condenser circuit, and will be found convenient. The coil, if assembled according to the drawings, will now be complete. A cross section of the induction coil complete is shown in Fig. 10.

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Interior Wiring.

GENERAL CONSIDERATIONS.

Perhaps no electrical subject that is closely allied with practical application is less thoroughly understood than wiring. It is not difficult for a man to acquire the art of stringing wire to lamps so that the latter will burn when the current is turned on; in fact, this acquirement often constitutes the sole accomplishment of many electricians, so called. To wire an electric lighting installation properly, however, is a requirement that is worthy of careful study and complete discussion. A good wiring installation should have the following attributes:

First, it must supply the lamps with current, and provide appropriate means of controlling the lights.

Second, the current must be distributed to the lamps at a constant pressure. That is, the voltage of the dynamo being constant, and also the number of lamps, the voltage from socket to socket should not vary beyond a certain amount.

Third, the wiring must comply with the insurance rules in force in the locality in which the work is done.

Fourth, a minimum amount of copper must be used in the accomplishment of the result.

The first requirement has to be met in any installation, for even the veriest layman can detect its lack, but the other essentials are too often neglected.

The next requirement is perhaps the most important as far as the general excellence of the result is concerned. Given a good, careful workman equipped with suitable tools, and materials allowed by the insurance company taking the risk, and let him keep this end in view and a poor job is an impossibility.

The third condition is usually compulsory.

The fourth condition is obvious as a matter of economy.

The first step in laying out a wiring installation is to secure a set of the architect's ground plans, for without them plans of some sort will have to be drawn. This, of course, involves a good deal of labor that it is worth making a considerable effort to save. Having secured the plans, they should be carefully studied with regard to the following points:

1. The area and shape of each room and the height of the ceiling, the nature and color of the decorations, if any.
3. The use to which the room is to be put.
4. The relative position of the room with regard to halls or other approaches.
5. The various mechanical conditions

about the rooms, such as the way the doors swing, the location of chimneys, water and gas pipes. Conditions that at first sight seem trivial may exert untold influence on the position of the wires.

The system is supposed to be determined when the contract is closed. The building and drawings should be carefully inspected with regard to whether the installation should be conduit wiring, moulding, cleat or knob work.

The next step is the number, arrangement and control of the lights. Both the owner, and the architect, if there is one, should be consulted about this. The electrician can give good advice as to the number of lights to efficiently do the work and can suggest their most efficient position. He can also suggest many beautiful special effects. In spite of the fact that he is usually the best posted as regards these matters, he must remember that the architect has ideas of æsthetic beauty and appropriate arrangement that have taken years to acquire, while the owner, however ignorant and ill posted on such matters as he may be, has the faculty of knowing what he wants. His judgment must be respected as he pays the bills, but both the architect and electrician, like good salesmen, can influence him to get the best, all things considered, and in fact they should do so, for that is the service for which he has engaged them. A satisfactory understanding in this coterie of authority will avoid much subsequent trouble.

NATURE OF ROOM.	HEIGHT.	NO. OF SQUARE FEET PER 16 C. P. LAMP.
Offices with desks	10 feet.	50, also localized near desks.
Reading rooms with tables	15 "	50, " " " tables.
Stores	15 "	80.
Dance halls	20 "	80.
Halls and lobbies	18 "	100.
Machine shops	15 "	150, and localized at machines.
Large town halls	25 "	120.
Churches	40 "	200.

No. B. & S. Gauge.	Diameter, Mils.	Area.		Weight and Length.			Ohms per 1000 feet. at 70° F.	
		Circular Mils (d^2). 1 mil=.001 in.	Square Inches ($d^2 \times .7854$).	Lbs. per 1,000 Ft.	Lbs. per Mile.	Feet per Pound.	Conductivity 97 per ct.	Current allowed by Und'wrtr's Code.
0000	460.000	211600.00	.166190	639.33	3375.7	1.56	.05077	175
000	409.640	167805.00	.131790	507.01	2677.0	1.97	.06403	145
00	364.800	133079.04	.104520	402.09	2123.0	2.49	.08170	120
0	324.860	105534.03	.082932	319.04	1684.5	3.13	.10177	100
1	289.300	83694.20	.065733	252.88	1335.2	3.95	.12828	95
2	257.630	66373.00	.052130	200.54	1058.8	4.99	.16188	70
3	229.420	52633.40	.041339	159.03	839.68	6.29	.20415	60
4	204.310	41742.57	.032784	126.12	665.91	7.93	.25742	50
5	181.940	33102.00	.025998	100.01	528.05	10.00	.32461	45
6	162.020	26250.50	.020617	79.32	418.81	12.61	.40934	35
7	144.280	20816.70	.016349	62.90	332.11	15.90	.51618	30
8	128.490	16509.00	.012966	49.88	263.37	20.05	.65086	25
9	114.430	13094.00	.010284	39.56	208.88	25.28	.82061	
10	101.890	10381.00	.0081532	31.37	165.63	31.38	1.03508	20
11	90.742	8234.10	.0064670	24.88	137.37	40.20	1.30496	
12	80.808	6529.90	.0051286	19.73	104.18	50.69	1.64554	15
13	71.961	5178.40	.0040671	15.65	82.632	63.91	2.07500	
14	64.084	4106.80	.0031469	12.41	65.525	80.59	2.61644	10

From the considerations that are the outcome of this discussion, the lamps can be placed and also the position of the switches controlling them. The number of the lights is best determined by experience and observation of similar conditions, but for the novice the first of the above tables has been given, simply as an approximate guide, and by no means as a standard of reference. Existing conditions of decoration, color and finish, will largely influence the result. Therefore, the table must be used with a great deal of discretion. In the table ceilings are assumed to be white and the walls of some light color.

The location of the lights as well as their number will be best determined by long experience, but a few general hints may not be out of place. The primary object of lights in a room is to see the other objects therein. Therefore, the light should be placed in such a position as to illuminate the object to be seen rather than to be situated where it will be the cynosure of observation. A well arranged source of illumination requires an effort to bring it within the field of vision, while its rays are shed upon every object that it is desirable to see clearly. A brilliant light thrust in the face of the observer at every turn contracts the pupil of the eye so much that difficulty is experienced in observing other darker objects which require examination. Moreover, the alternate expansion and contraction of the iris which such an arrangement entails is both tiresome and injurious to the eye. If the light is to have a decorative effect, such as in a theatre or place of entertainment, its position may be more prominent. If, however, utility only is desired, the lights should be placed as far above the horizon line as convenient, which line is five feet from the floor for the average man. With these hints, the advice of the architect and owner and the convictions of his own judgment, the student of wiring, we will suppose, can successfully locate the outlets, when he is then ready to lay out the wiring details.

To do this properly, he must have a knowledge of the conditions as already indicated; he must be acquainted with electrical properties of wires, and thoroughly conversant with Ohm's law. Further than this he must know the loss that the system is to have in the wiring at full load.

The line loss or loss of energy in the wires is equal to the current flowing in them multiplied by the voltage necessary to force that current through them. It is a loss of energy and in strictly accurate terms should be measured in watts. However, this loss becomes apparent by a loss of pressure at the end of the line, as the current through every part of the circuit remains the same. The brilliancy and life of an incandescent lamp depends directly upon the voltage to which its terminals are subjected; hence, a loss of pressure in the line is far more important to the wireman than the actual energy consumed therein. Therefore, line loss is always measured in volts.

It is customary to assume a certain line loss and to so calculate the wiring that the loss or volts drop from the dynamo to any lamp socket will be equal, whatever the conditions of load. This is never possible to exactly realize, but it should be aimed at as an ideal.

The line loss in interior wiring is rarely more than five per cent of the total voltage. In isolated plants the dynamo may be adjusted to rise in voltage the amount of the line loss as the load comes on, and, therefore, it is theoretically possible to so wire a building that the voltage at any lamp will be absolutely constant whatever the load.

To correctly lay out a wiring installation, a thorough understanding of Ohm's law is necessary. It is not merely sufficient to remember $C = \frac{E}{R}$, $R = \frac{E}{C}$ and $E = CR$; the wireman must be able to intelligently apply them to the calculations that he may meet. Extreme accuracy is never necessary, for after having calculated the proper resistance per foot, or the area of a wire, the nearest standard size must be selected, thus sacrificing the accuracy of calculation. Therefore, a few good and quickly applicable formulæ should be sought.

Some electricians prefer to calculate the area of the wire, which they express in circular mils, while others prefer to obtain the resistance per foot of the proper wire. Either method is short and satisfactory, but with either a wire table is necessary, unless the data regarding standard wires is memorized.

In American practice the Brown & Sharp gauge is used almost exclusively, and a table of dimensions is herewith given:

The first column gives the gauge number; the second, the diameter in mils or thousandths of an inch; the third, the area in circular mils. The square of the diameter is proportional to the area and fixes the size of the wire just as definitely. This diameter in thousandths of an inch, when squared, gives what is called the area in circular mils, and designates the size of the wire, without multiplying by .7857, our inconvenient constant. The fourth column gives the actual area of the wire in square inches. The advantage of the next three columns is obvious. The next column gives the resistance of the wire in ohms per thousand feet, assuming a temperature of 70 degs. F. and a copper of ninety-seven per cent of the conductivity of pure copper. The last column gives the safe carrying capacity according to Kennelly's experiments, which are generally followed throughout the world, though somewhat increased in later codes. If the current is below these limits, the job is sure to pass on that point whatever insurance company takes the risk. If a job is to be wired for a few per cent line loss, there is little danger of exceeding the current allowed by insurance companies, except in the case of lamps very near the source of supply. For such short distances a few per cent drop can be obtained only by using a small wire, and often in such cases it will be necessary to sacrifice the desirable condition of uniform drop throughout the installation in order to comply with insurance regulations as regards maximum capacity of wires.

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Repair of Electric Railway Apparatus.

GENERAL ELECTRIC CONTROLLER.

BY W. E. SHEPARD.

The controller adopted by the General Electric Company is unique in a number of its details. The Thomson-Houston Company controlled fundamental patents on electric magnetic devices used for blowing out or breaking of an arc, and early adapted the principle to the rheostat controller put out by that company. This principle has been incorporated in the later "Series Parallel" controllers and has proven to be a most invaluable adjunct.

Of the several types which have been put upon the market by the General Electric Company, the forms known as the type K and K2 are the most commonly known. The two are almost identical in detail, the chief difference being that type K2 is arranged for one more section of resistance than type K, this requiring one main cable and terminal, and one contact in addition to that found in the K. The controller is also made slightly larger in its dimensions and is heavier. A description therefore of the K2 will apply throughout to the K, bearing in mind only the difference of an added step in the resistance of the former.

Fig. 1 shows very clearly the interior of the type K2 as now made. At the left of the center of the figure, extending from the top downward, the main controlling contact is shown, consisting of arcs or segments of circles, each of which terminates in a removable copper contact tip. The twelve contact fingers are shown at the left. Above, at the right, are shown the eight fingers and contacts of the reversing cylinder.

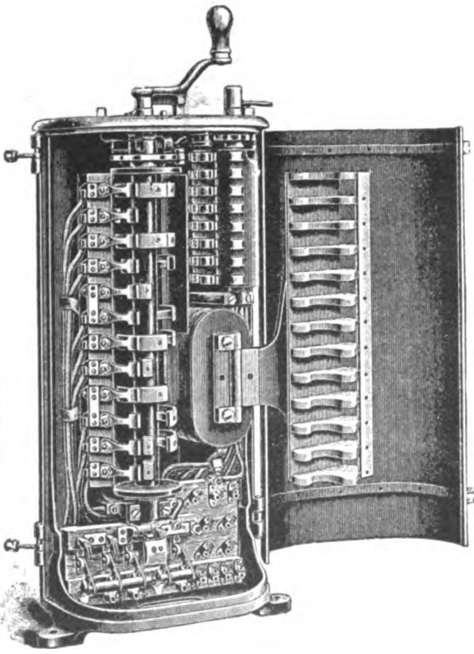


FIG. 1.—K2 CONTROLLER.

Near the bottom of the controller at the left are the two cut-out handles, the raising of which cuts out either No. 1 or No. 2 motor as may be desired, at the same time locking the main controlling drum so that it can not be turned to the points corresponding to the parallel combination, no matter which motor may be cut out of the circuit. Near the bottom at the right is the main terminal board with its fifteen main terminals and just above is seen the heavy electro-magnet, designed for blowing out the arcs formed at the tips of the contact fingers.

The magnet is connected in on the main circuit, and whatever current is being used by the car at any time passes through its coil, so that the heavier the current and the consequent tendency to arc, the stronger is the field magnetism of the magnet and its corresponding power for blowing out the arc. One pole of the magnet is hinged and swings outward, exposing the fingers, as it is shown outlined against the cover of the controller. When closed this pole is directly over the finger tips, the other pole being formed by the heavy iron casting composing the back of the controller.

The action of this controller is all that can be desired. It is unusually well built and fitted and will endure very severe abuse. Its repairs are confined almost entirely to trimming or replacing of fingers and the small tips on the cylinder, and these wear for a very long time, ten or twelve months easily.

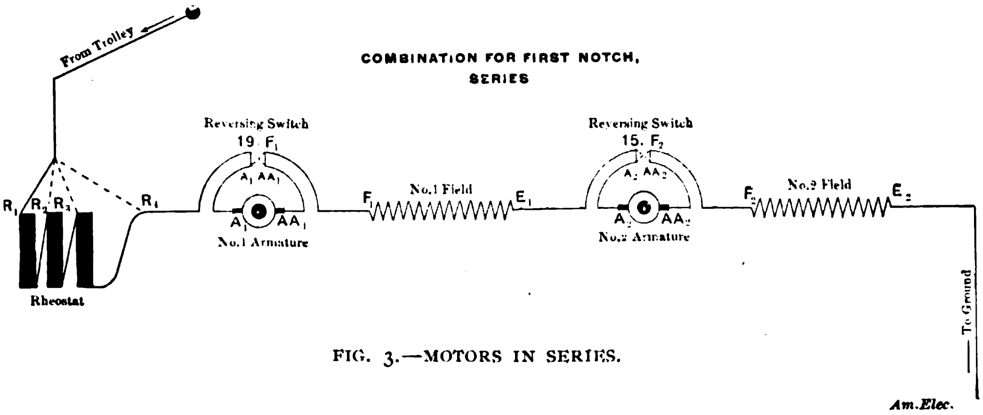


FIG. 3.—MOTORS IN SERIES.

One thing has to be guarded against, which is true of all controllers with sliding fingers of this sort, namely, the setting of the springs on the contact fingers too tight, for if too stiff there is a tendency to cutting, and this once started, the finger tips and entire cylinder ring grind away very rapidly. This will be prevented by easing spring slightly and by moistening the ring by just a touch of vaseline or paraffine. The former is best and it is a good practice to apply it to all the controller wheels whether cutting or not, but it must be used very sparingly, as too much is far worse than none at all.

An outline of the wiring connections of the controller is shown in Fig. 2.

We will trace the path of the current as the power is applied on three of the notches only, the remaining joints differing only in that they have more or less resistance in their circuits, the combinations themselves being very nearly the same.

First, when running on the *first* notch, both motors in series, also all the main resistance in circuit as shown in Fig. 3.

The current coming in from trolley goes to the main terminal T, then passes through the coil on the flow-out magnet to contact finger T, there to contact finger R—to terminal R; through all of rheostat back to terminal R_4; to terminal 19 on reverse cylinder; to A_1 on reverse cylinder; to terminal A_1; through No. 1 armature back to terminal AA; to AA_1 on reverse cylinder; to F_1 on reverse cylinder; to terminal F_1; through No. 1 field back to terminal E; to contact 15; to terminal 15; to 15 on reverse cylinder; to A_2 on reverse cylinder; to terminal A_2; through No. 2 armature back to terminal AA_2; to AA_2 on reverse cylinder; to F_2 on reverse cylinder; to terminal F_2; through No. 2 field back to G or ground, one side of No. 2 field coil being connected direct to ground cable.

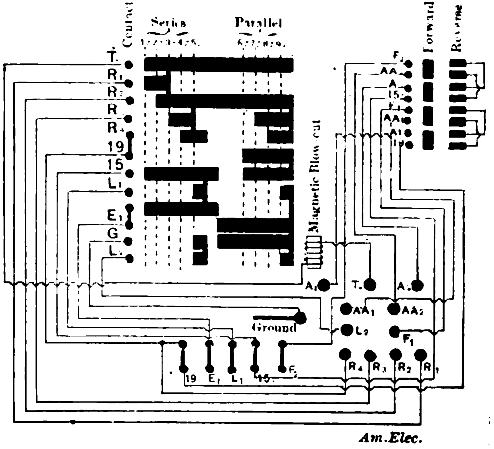


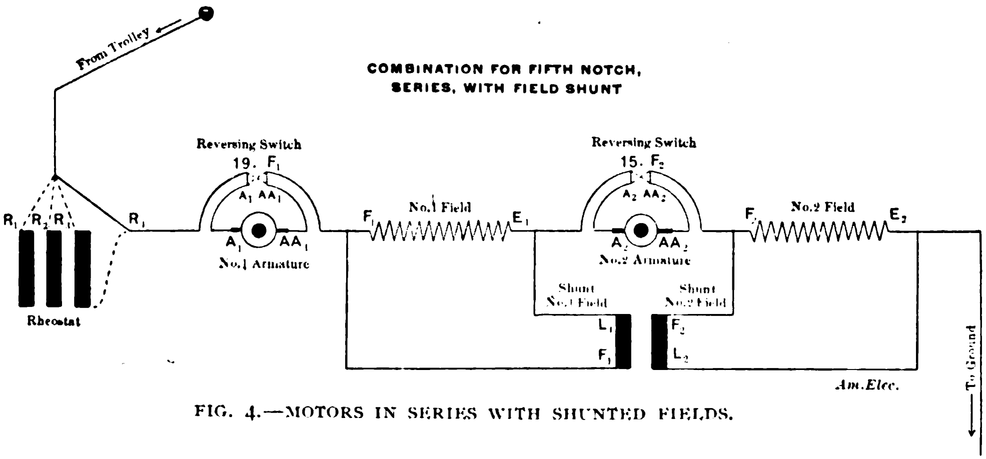
FIG. 2.—WIRING PLAN.

One arrangement peculiar to the G. E. motor is the use of a shunt resistance around the field coil of each motor. This resistance consists of thin ribbons of German silver, in appearance similar to the iron ribbon used in the main rheostat and is used on combinations four and seven in the K and five and nine in K2 controllers.

When running on these points all the current passes through the armatures of the motor as usual, but part only passes through the field coils; a considerable portion, depending on the speed of the motors, resistances of the circuits, etc., flows through this shunt resistance, the effect of which is to leave the fields of the motor practically of the same strength as when running on the notch immediately preceding, while at the same time adding to the strength of the current flowing in the armatures by whatever amount passes through the shunt. The effect is, of course, an added effort of the motors with a corresponding increase in the speed.

The path of the current when running on notch four of type K in five of K2, is outlined in Fig. 4, and in detail as follows:

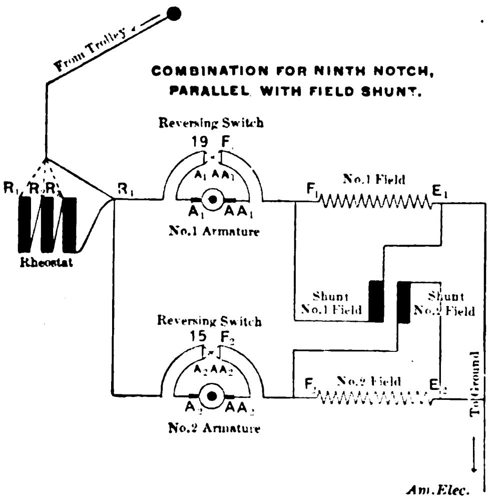
Current coming in from trolley passes through the blowout coil from main terminal T, to contact T, passes to contacts R_4 and 19; to terminal 19, on reverse cylinder; to A, on reverse cylinder; to terminal A_1; through No. 1 armature back to terminal AA; to AA_1 on reverse cylinder; to F_1 on reverse cylinder; to terminal F_1; through No. 1 field back to terminal E; to E_1 contact and to contacts 15 and L_1. Here notice the closing of a circuit coming in from F_1 in the motor cables where it is permanently connected, and passing through the shunt resistance to terminal L_1, thence to terminals L_1 and 15, and uniting with the current already flowing to 15, from direct through the field of No. 1 motor. From contact 15 the current flows to terminal 15; to 15 on reverse cylinder; to A_2 on reverse cylinder; to terminal A_2; through armature No. 2 back to terminal AA_2; to AA_2 on reverse cylinder; to F_2 on the reverse cylinder; to terminal F_2; through No. 2 field back to E_2 and G or ground. Here notice at G the closing again of a second circuit which comes in from L_2. This circuit is, like the preceding, permanently connected in the cables to F_2 and current from it comes in at this point, L_2, often having passed through another shunt resistance, the two currents uniting flow together to ground.



Am. Elec.

FIG. 4.—MOTORS IN SERIES WITH SHUNTED FIELDS.

For the first point in parallel, notch No. 6 on the K2 the combination of field, armature and resistance is as shown in Fig. 5. For the last notch, it is shown in Fig. 6.

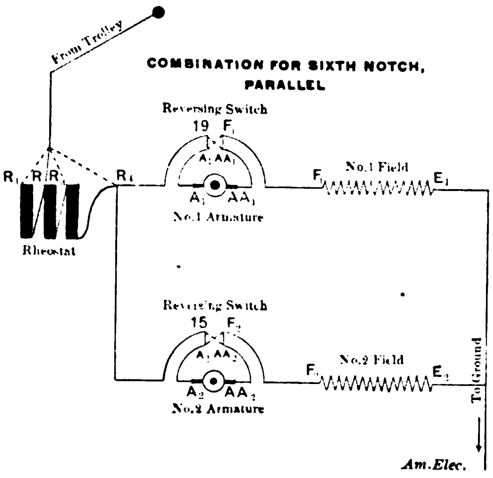


Am. Elec.

FIG. 6.—LAST NOTCH IN PARALLEL.

For the first point running in parallel circuit the details of the path of the current are as follows:

The current, coming in from trolley to main terminal T, passes through the blowout magnet coil, thence to contact finger T_1; to contact finger R^2; to terminal R_2; through part of rheostat back to terminal R_4. Here the current divides, part goes to terminal 19; to 19 on reverse; to A_1 on reverse; to terminal A_1; through No. 1 armature back to terminal AA_1; to AA_1 on reverse; to F_1 on reverse; to terminal F_1; through No. 1 field back to terminal E_1; to contact finger G; to ground. Part goes from terminal R_1, to contact finger 19; to contact finger 15; to terminal 15; to 15 on reverse; to A_2 on reversal; to terminal A_2; through No. 2 armature back to terminal AA_2; to AA_2 on reverse; to F_2 on reverse; to terminal N_2; through No. 2 field to connection on ground cable back to G and to ground.



Am. Elec.

FIG. 5.—FIRST NOTCH IN PARALLEL.

◆

Faults in Dynamos.

Practical hints such as are embodied in the following article are often of much service, provided that they possess simplicity and can be availed of with means commonly at hand. The object here is to give a few simple methods of attaining certain ends, without attempting to make a connected narrative.

Electrical machinery frequently develops defects in insulation or circuit continuity, commonly called faults. A few simple tests with a magneto bell usually serve to locate the member of the machine in which they lie. Such tests also disclose the nature of the fault, but the determination of its exact location for speedy repair is not, as a rule, considered an easy thing to do, and is usually left to the repair man. In finding the fault, he may take down a lot of good work unnecessarily, and therefore a few hints on this subject may be useful.

Take, first, the very common fault of a ground in a closed coil armature, which can readily be detected by ringing a common magneto bell between the shaft and the commutator segments. The question at once arises, What coil of the armature, or segment of the commutator, is grounded? Disconnecting the coils for separate testing is very laborious, and much may be done that afterward proves unnecessary.

If a closed coil armature circuit could be untwisted from its iron core, and stretched out without disturbing its continuity, it would have the appearance of a loop on which the commutator bars are spaced at equal linear distances, as shown in Fig. 1. This would be the case whatever the system of winding, whether ring or drum. Some multiple circuit windings would present slight modifications of this appearance when stretched out as indicated, but the method of testing would be the same. To locate the defective coil or segment, pass a very light current—one-half an ampere or less—into the shaft of the armature and out through a convenient commutator segment. This current may be conveniently obtained by placing the armature thus connected in series with a single incandescent lamp, and supplying the combination with current at the rated voltage of the lamp. If this current is not available, an ordinary dry battery with no series resistance will supply sufficient current for the purpose. Procure a telephone receiver, which may be had for about a dollar, and connect one terminal of it to the armature shaft, as shown in the accompanying sketch. If the free terminal now be touched to any part of the armature circuit, a sharp click will be heard in the receiver. This click will vary in loudness according to the part of the armature circuit touched, and a place can be found where the noise will be a minimum and perhaps cease altogether. Touch the segments of the commutator with the free terminal, noting the one at which the noise in the receiver is the least. That segment and coil are probably the ones affected, as the indication is that they are, electrically, very near the shaft. Disconnect the wires from the segment and test the latter for ground with a magneto. If its insulation is all right seek the other end of the coil, and disconnect that also. Then test the coil thus isolated, and if the work has been carefully done, the fault will probably be found.

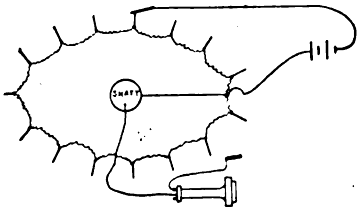


FIG. 1.

In taking off the defective coil, look carefully at the driving pins, for often the trouble may be found there and corrected without taking off a single binding wire. Of course, if the difficulty is still elusive, the coil may be taken completely off, but the magneto should be rung at frequent intervals during this process. A good workman should not be satisfied with simply correcting such a difficulty; he should accurately ascertain the cause, for it may be that with this knowledge he can prevent the recurrence of the fault. At all events he will know where to look for trouble when a similar case occurs.

Grounds are quite as frequent on field magnets as on armatures, and just as easy to locate. The magneto will detect the spool and the section, if the spool is divided, but to determine the location more exactly recourse must be had to other methods. A ground on a field magnet can only occur on the layer nearest the magnet core, or on the ends of the bobbin. It frequently occurs on the leading in wires. To locate it, connect across the terminals of the field magnet a long, fine iron wire, as shown in Fig. 2. The finer the wire on the field magnet, the more necessary is the fineness of the iron wire. It should be as long as convenient, and should be coiled back and forth upon a board in which light nails are driven for the purpose, as shown in Fig. 3. The best length for the wire is that which will give it a resistance exactly equal to the resistance of the magnet coil to be tested. If the latter is known, the proper length of wire can be readily calculated by means of a suitable table. Having arranged the wire and connected it as indicated, pass a light current through the two circuits, as shown in the sketch. Connect the telephone to the core of the magnet at one terminal, and with the free terminal search along the iron wire circuit for a point where no click occurs in the receiver on making and breaking contact. If the magnet be wound with a uniform size of wire, as is usually the case, the fault will lie at a proportionate distance from either terminal in the coil circuit.

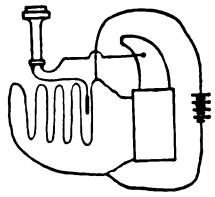


FIG. 2.

Now, a fault of this kind can only occur, either at the terminals themselves, on the layer next the core or somewhere on the ends of the coil. Therefore, a little shrewd guessing will locate it. If the point of silence is found near the end of the iron wire circuit, the ground may be looked for where the corresponding coil terminal emerges from the winding. This is a location where grounds in such coils are extremely likely to exist, and they can usually be repaired without unwinding a single turn. If the silence point is found a short distance from the inside terminal, the fault is, probably, on the layer next the core, and if the coil cannot be slipped off the entire unwinding of the bobbin is often necessary. If the silence point occurs anywhere else on the iron wire circuit, the fault will be found at one of the inner layers next one of the end collars. In this case, before unwinding it will be found best to remove the end collars and look for the trouble there, for it can, probably, be found and perhaps repaired without tearing the coil to pieces further.

One of the most difficult faults to detect and locate in a dynamo is what is called a "flying" short circuit. An armature that is apparently all right, and tests out free from trouble, will act strangely when in service in a machine, and will, probably, cause intermittent sparking at the commutator, which will keep step with the revolutions of the machine, or it may refuse to build its voltage. Moreover, the trouble will sometimes come, and then disappear for an interval in a most bewildering manner. If these symptoms are so pronounced that this difficulty is suspected, shut the machine down, and connect across its terminals a length of iron wire, precisely in the same way as was indicated in the test of the magnet coil. As an armature has a very low resistance, unless the machine be of high voltage this wire need not be either very long or fine. Three or four feet of No. 00 B. & S. will answer in most cases. Pass a current through the armature, and connect the telephone, as shown in the sketch (Fig. 4). Connect the terminal, to a place on the wire where, when a momentary touch is given, the receiver gives no click. Being careful not to turn the armature, and keeping the receiver to the ear, feel the armature all over, pushing and pulling the wires. A flying short circuit, it may be stated, is the contact between two armature wires when the machine is in motion, but which ceases when the machine comes to rest. Therefore, if this connection is made by pushing and pulling on the wires, the fact will at once be made known by a click in the receiver. By this means the trouble is not only discovered, but is also accurately located.

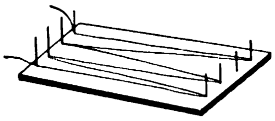


FIG. 3.

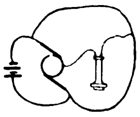


FIG. 4.

A short-circuited field magnet, especially if it be a shunt coil, is not easy to discover. A shunt coil will not indicate that it is partially short circuited by any misbehavior of the machine, except that a little more rheostat has to be cut out in order to make the machine keep up its voltage and the field coils run hotter, especially the ones not short circuited. A common way to detect and locate this trouble is to measure the resistance of the coil and compare it with that of its mate, assuming that if there is a difference of any amount, that the coil of least resistance is short circuited. This is a very good method if the experimenter is sure in the first place that the two coils were originally of the same resistance; if, as is often the case, there is but one field coil, the method is not applicable. A very good way is to weigh the coil if it can be taken off, and with the aid of a suitable table, the resistance that the coil ought to have can be calculated, if the size of the wire is ascertained. Almost every trade catalogue of insulated wire has a full set of tables which are very useful for such work, and the makers of wire are always glad to mail a copy on application. If the coil cannot be taken off, determine the number of turns and also the number of layers. The number of layers cannot always be actually counted, but it can be estimated if the manipulator is at all shrewd. A little figuring gives the length of the wire on the bobbin, and for calculating its resistance this factor is quite as efficient as the weight. In either case, with a little care the error need not be over a few per cent. The method is not altogether satisfactory, but it is the most convenient one available.

Short circuits in an armature circuit, on the other hand, are often self indicative, both in location and amount. If the short circuit is a strong one and occurs while the machine is in operation, the short circuited coils will probably burn out before help can reach them. Something must go, either the coil or the short circuit. Some writers caution their readers that the coils of the armature are very liable to short circuit by the dragging over of the copper from one bar to another, and that if it is not promptly attended to the armature is liable to burn out. The fact of the matter is that these miniature short circuits burn out as fast as they occur and do no other damage than contribute to the roughness of the commutator. Often when the commutator scintillates at other places than under the brushes, the current is said to be jumping the segments when it is really burning out the little short circuits. The voltage between bars on a well designed machine is so low that the distance that it could jump across a gap of air is almost microscopic. In following articles open circuits and other faults will be considered.

◆

The Steam Engine Indicator Card.

The principles and calculation of the steam engine indicator card are so comparatively simple that no engineer should permit himself to lack knowledge of the same. That he does not indicate the engine which he has at present under his charge should be rather considered as unfortunately depriving him of useful experience than be allowed to serve as an excuse for neglecting the subject. Owing to the low cost at which indicators can now be purchased, employers are more and more likely to demand a knowledge of the indicator as part of the qualifications of their engineer, not only as a means of checking the consumption of fuel, but also to avoid the cost of an indicator expert should an engine at any time develop irregularities in working, or to discover at an early stage the defects that would lead to such irregularities.

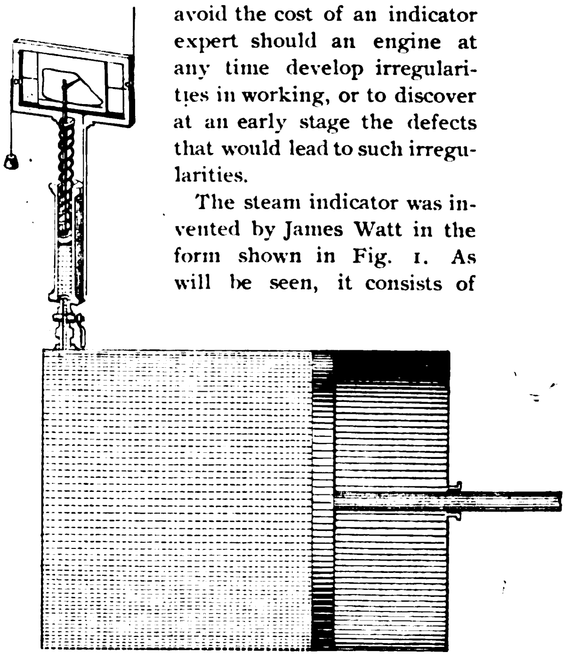


FIG. 1.

The steam indicator was invented by James Watt in the form shown in Fig. 1. As will be seen, it consists of three principal parts: First, a piston and a small cylinder communicating with the extreme end of the engine cylinder, to which piston is attached a rod carrying at its extremity a pencil; second a spiral spring above the indicator piston, which opposes the pressure of the steam underneath; and, finally, a board having motion coincident with that of the engine piston, such motion being derived from the engine piston rod or crosshead by means of some kind of gear which reduces the stroke of the cylinder to the travel of the board. Upon the board is secured a piece of paper, and when the indicator pencil is pressed against this, the horizontal travel of the board and vertical motion of the indicator piston combined, produce a diagram such as is shown in the illustration.

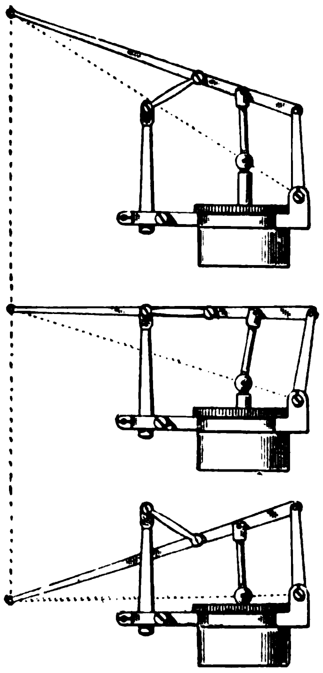


FIG. 2.

For the extremely low engine speeds of former days, the above indicator answered its purpose admirably, but, it is scarcely necessary to say, would be entirely useless with present engine speeds. A modern indicator is shown in Fig. 3, which it will be seen, only departs from the original Watt indicator in detail. The improvements in modern types, aside from superior workmanship, consist as follows: First, the reduction of the stroke of the indicator piston by means of various lever arrangements, whereby the vertical pencil motion is made several times greater than that of the indicator piston; this reduces the greater inertia due to longer stroke, which inertia causes the indicator piston at any instant to be thrown ahead of, or kept lagging behind, its true position, thereby falsifying the indicator record. Second, the substitution for the board and weight of the Watt indicator, of a cylinder drum and spring, which greatly reduces the weight and size of this moving part and enables it more quickly to respond when the stroke is reversed twice each revolution of the engine.

In Fig. 3, the multiplying link Fig. 2 is illustrated in detail. As will be seen, the pencil always moves in a straight line, and the distance through which it travels is much greater than the corresponding travel of the rod directly attached to the indicator piston. The total travel of the pencil of the indicator shown is 2¾ ins., and that of the indicator piston only one-fifth that amount, or but little more than ½ in.

Referring again to Fig. 1, since the board upon which the indicator card is mounted has motion coincident with that of the engine piston—that is, is at half stroke, quarter stroke, etc., at exactly the same instant that the engine piston is at the same point of its stroke—it is evident that the indicator diagram truly represents the variation of pressures in the cylinder during the entire stroke. It should be added that in taking indicator cards, the pencil is pressed against the revolving drum before the steam is turned on the indicator, whereby a horizontal mark is made, called the atmospheric line; this line is not only useful as a line of reference, but also serves in measuring distances along the indicator card, since its length is the exact length of the card, which length otherwise might be incorrectly determined by measurement from the cards, owing to their irregularity of shape.

To illustrate, suppose we had an indicator card of a cylinder of thirty-six inches stroke, and wish to know the pressure in that cylinder at twenty-four inches from the commencement of stroke, or in other words, at two-thirds stroke. Find the point two-thirds along the length of the indicator card (measuring along the atmospheric line) and measure the length of that portion of the vertical or pressure line at this point which lies between the upper and lower curves of the card; if we suppose this length to be 1¼ ins. then, if the indicator spring is a forty pound spring—that is, is extended or compressed one inch when the steam pressure below the indicator piston rises or falls through forty pounds per square inch—the pressure in the engine cylinder at two-thirds stroke at the time when the card was taken will have been $40 \times 1\frac{1}{4} = 50$ lbs.

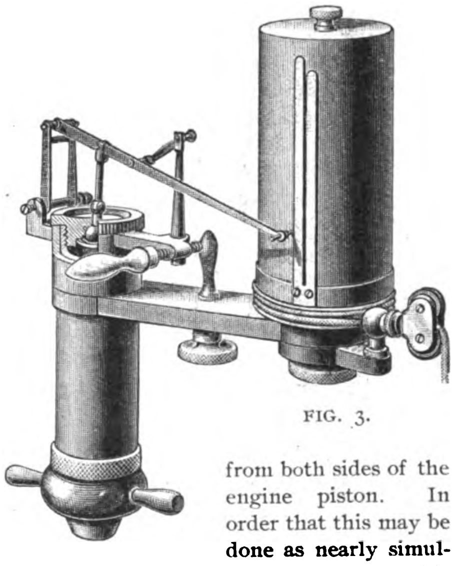


FIG. 3.

In order to obtain the correct horse power of an engine indicator, cards must be taken from both sides of the engine piston. In order that this may be done as nearly simultaneously as possible and with a single indicator, pipes from either end of the engine cylinder lead to a common indicator connection with a three-way cock. The two cards taken by this arrangement are combined, as will be seen later, the exhaust line of one being usually superimposed on that of the other. It would, of course, be simpler in beginning the study of the indicator card to show but a single card, as illustrated in Fig. 1, but in the end more would be lost than gained by this, as at first in applying what is learned, one would be apt to be confused by the double card.

As intimated above, the usefulness of the indicator diagrams is two-fold—for the calculation of horse power and for the purpose of determining whether valves are properly set, for detecting piston leakage, etc. The calculation of indicator cards will first be taken up, the other points being left for treatment in future articles. In order however that such calculations may be intelligently made, it is necessary to understand the measurement of mechanical energy, or in other words, what foot pounds and horse power actually mean.

Foot Pounds.—If a man lifts a weight of, say, one pound one foot from the ground, he does a certain amount of work, which quantity is known among engineers as one foot pound. If five pounds are lifted one foot he does five foot pounds of work; or if a one pound weight is lifted five feet he does five foot pounds; or if five pounds are lifted five feet he does twenty-five foot pounds of work. Similarly, if it requires a pull or push of fifty pounds to stretch or compress a spring one-tenth of a foot, the work done is five foot pounds. Or if we have a steam cylinder of one-hundred square inches area moved by steam at an average pressure of fifty pounds per square inch, 5000 ft. lbs. of work are expended by the steam shoving the piston one foot; if the stroke is two feet and the piston is that of an engine making 120 revolutions or 240 strokes per minute,

$$\underbrace{2 \times 240}_{\text{distance per minute.}} \times \underbrace{5000}_{\text{pressure.}} = 2,400,000$$

foot pounds of work will be done per minute. From the above illustrations it will be seen that the work done by a force is the product of that force into the distance through which it is exerted.

Horse Power.—When James Watt commenced the manufacture of his steam engine, he was met by the question of rating and as the engine was intended to displace horses, it was considered desirable from a commercial standpoint to adopt a rating whereby the power of an engine could be directly compared with the power capable of being exercised by a horse. To this end Watt experimented with a horse lifting weights from a deserted mine shaft, and came to the conclusion that a horse could do about 22,000 ft. lbs. of work per minute; that is, if the weight were, say, 200 lbs. the horse used in his experiments could continuously lift it at the rate of 110 ft. per minute. In order, however, to give "good measure" to his customers, he added fifty per cent, thus fixing the horse power at 33,000 ft. lbs. per minute, at which it has since remained. It should be added that a draught horse may work at the rate of five horse power for five or ten minutes and at even a greater rate during a shorter length of time. Returning now to the example of the engine in the preceding paragraph, since 2,400,000 ft. lbs. of work are done per minute, the horse power is

$$\frac{2,400,000}{33,000} \text{ or } 72\tfrac{2}{3} \text{ h. p.}$$

Knowing now what a horse power actually means, the calculation of an indicator card can be undertaken with confidence. This will form the subject of an article in the next issue.

Lessons in Practical Electricity.

One of the chief difficulties encountered in first taking up the study of electricity arises from the manner in which that agent is popularly regarded. When one approaches a subject popularly surrounded, as is that of electricity, with a dense cloud of mystery, and dealing with what is supposed to be unique among all the forces of nature and one which so far has absolutely eluded the grasp of man, the slightest difficulty encountered is naturally apt to be magnified. At the beginning, therefore, any idea that electricity is peculiarly mysterious should be dismissed, particularly as such an assumption is entirely untrue. The nature of gravity, light or heat is in the same category with electricity, yet we hear little or nothing about their mysteriousness. Gravity, in fact, is still more elusive than electricity, for while hypotheses have been advanced that seem to reasonably account for the nature of the latter force, the action of the force of gravity in causing a large body to attract a smaller one is as yet unexplained by any generally accepted hypothesis. The question, therefore, Why does a stone tend to fall to the earth? is actually more difficult to answer than the more frequent one, What is electricity? We do not for all that, however, look upon, for example, a clock actuated by weights as a wonderful machine, and similarly, there is no reason why an electric motor, as far as the force actuating it is concerned, should be regarded differently. The nature of electricity, in fact, concerns us no more in dealing with its manifestations than the nature of gravity does the maker or user of a pile-driver, or the atomic constitution of water, though one of the most wonderful of liquids in its properties, does the steam user. It is a question that may be left entirely aside in the study of the manifestations of electricity as one having no bearing in practical problems, and of no other than a curious interest except to those accustomed to the study of abstract physics. Thought of it should therefore not be permitted to intervene and confuse the understanding or relax effort when engaged in the consideration of its effects, which alone concern us in the study of its applications.

Another false notion which should be avoided is that contained in the by-words "Electricity is merely in its infancy," when used in the sense that but little is known of the possibilities of electricity. The laws controlling the manifestations of electricity are as firmly established as those of any other branch of physical science, and the application of those laws to practical purposes is even more simple. Moreover, all of the more important principles concerning practical electricity, instead of being recent discoveries, were founded in the first half of the present century. From the moment Faraday showed how the electrical current may be generating by mechanical means, the dynamo became a possibility and its development as a practical machine merely awaited the necessary commercial conditions. As examples of early developments of electrical appliances, it may be pointed out that about 1846, Starr, an American, exhibited a chandelier of lighted incandescent lamps before Faraday, while the automatic arc lamp dates from 1850 or even earlier. The alternating current transformer is merely a modified Ruhmkorff coil, which latter apparatus dates from the first half of the century, and the electric motor was one of the very earliest electrical applications. Had the future demand for electricity been anticipated in the day of Faraday, it is probable that the dynamo would have been perfected at that time; conversely, if a cheap source of current had been available in the first half of the century, the development of arc and incandescent lighting might have been advanced thirty years or more.

It will thus be seen, that while fifteen years ago commercial electricity was in its infancy, this was far from being true with respect to the principles upon which it depends. This distinction between commercial development and the progress of electrical science proper should, therefore, be borne in mind when taking up the study of electricity, as one is apt to be handicapped when laboring under the impression that present knowledge is so ill founded that it may at any day become of no consequence through further discoveries in every department. It may be added that there is little reason to believe that any further startling developments will occur in the present branches of commercial electricity, though as much cannot be predicted with the same degree of confidence concerning the new field opened up by Hertz and Röntgen—that of electric waves or radiations.

While, as just pointed out, the student of applied electricity need not be concerned with the nature of the force itself, yet in order to assist the understanding he may, with profit, make assumptions which, by association with ideas already possessed, will assist in grasping new ideas, even though, in fact, widely different. For example, he may consider that electricity is a fluid or is composed of two separate fluids, and that its laws are similar to those relating to the flow of water or other liquids, etc. In fact, such methods of assistance in learning a new subject by comparisons relating with - other branches of knowledge already familiar, are extremely useful, but it should never be lost sight of that they are to be employed only as make-shifts, and that the assumptions are never to be confounded with realities. This caution is one that should be heeded, as in dealing with some branches of the alternating current the fluid idea is likely, if too firmly fixed in one's mind, to increase the difficulty of understanding.

The first ideas to be taken up in the study of practical electricity are those relating to electromotive force, electric current and electric resistance. That is to say, the *cause*, electromotive force; the *effect*, current; and *resistance*, that which modifies the effect, permitting it to be greater or smaller.

It will readily be seen that these three factors appear in every department of nature, though under different aspects. A horse, for example, in pulling a wagon exerts a force which produces speed as an effect, the speed being greater or less according to the resistance offered by the road, that is, whether the road is smooth or rough. Similarly, the amount of water (current) that in a second will flow from a given pipe will depend upon the head or pressure (force) and upon the resistance the pipe offers to the flow from roughness of its surface, bends, etc.

The latter or hydraulic analogy offers perhaps the simplest means for illustrating electromotive force, current and resistance. As just implied, the head or pressure of water corresponds to the electromotive force, the quantity of water flowing under such head or pressure to the electric current, and the size and resistance of the pipe conducting the water, to the size and resistance of the electric conductor. From this it will be seen that we may have a very large head or pressure (electromotive force) and yet have a small flow of water (current); for in, say, a ¼ in. pipe, but little water would flow under a head equal to that of Niagara Falls, or with a corresponding pressure of seventy pounds per square inch at one end of the pipe. On the other hand, we may have a very small head and large flow, as in a river flowing through a level country, or in a very large pipe connecting two bodies of water differing slightly in level, these cases corresponding to a low electromotive force and a conductor or large section and short length—that is, of very small resistance.

It will be noted that the analogy is not entirely satisfactory, for in the case of water under a given head only a certain limiting amount of water will flow through a given pipe even if the pipe possesses absolutely no friction; while with a given electromotive force an electric conductor would conduct, dependent upon its resistance, any amount of current up to a point where it is melted, which point may be greatly extended by cooling the wire with air or water, the latter method being often employed in connection with the resistances used for absorbing power when testing electrical machinery. The analogy, however, is useful in illustrating, first, that electromotive force resembles a head or pressure of water; second, that the flow of water under a head or pressure resembles the flow of electricity under an electromotive force; third, that the frictional and other resistance encountered by water flowing in pipes is somewhat comparable to the resistance of electric conductors; and, finally, that though we have a large head or pressure (electromotive force) it does not follow that there will be a large flow of water (current), as this latter depends upon the size and condition of the pipe used (resistance of the conductor); and, conversely, that a low pressure or head of water (low electromotive force) may cause a large flow of water (current) if the pipe used is large (the electric conductor of low resistance).

The centrifugal pump affords one of the most satisfactory means to illustrate roughly the generation and flow of direct current. In Fig. 1, suppose *AO* to be a centrifugal pump continuously circulating water through the pipe, *A R O*, the pump corresponding to a dynamo. If, now, we had a pressure gauge, *G*, with one end connected at *A* and the other at *O*, it would register the pressure required to force the water around the circuit;

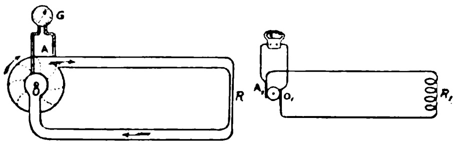


FIG. I.

that is, would correspond to the electromotive force at the binding posts, A_1 O_1, of a dynamo; the amount per second of water being circulated would correspond to the electric current, and the friction of the main pipe and the small pipe, R, would correspond to the electric resistance of the wire circuit, which in this case is made up of the resistances of the conductors and, say, of an electric heater, R_1. In Fig. 2, a circuit is represented containing small water motors in *series*, which may be supposed to correspond to electric motors in an electrical circuit, or to arc lamps; we may, for instance, suppose M_1 to be a series motor and A_1, A_1, A_1 to be arc lamps. If in such a hydraulic circuit a gauge were placed with a connection on either side of, say, M, it would register a pressure corresponding to the drop caused by the resistance of the water motor to the current of water passing through it. If, for example, a pressure of two pounds showed at each of the water motors and another pound were lost by the friction of the pipe and pump, a gauge at the centrifugal pump would show $6 \times 2 + 1 = 13$ lbs., which in an electric circuit would correspond to the sum of electromotive forces measured by, say, a voltmeter at A_1 O_1. Fig. 3 corresponds to an electrical circuit having its receivers, such as incandescent lamps, L'_1, L'_2, L'_3, and an electric heater, R', in *parallel* or *multiple arc*. In this case, it will seem that if the size of the parallel pipes, L_1, L_2, L_3 and R, is very small compared with that of the main pipes, S, approximately the same amount of water (current) will pass through each, and the pressure (voltage) at, for example, R, will be but little less than at L_1 (L'_1).

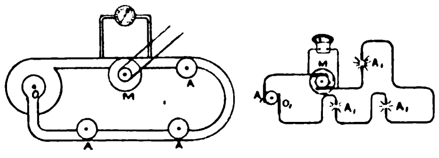


FIG. 2.

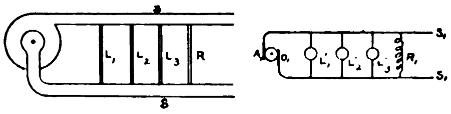


FIG. 3.

It will also be evident from Fig. 2, that since, in series connection, the same water or current passes through all of the devices in circuit, the size of the conducting pipe or wire will be smaller than if the same devices were connected as in Fig. 3; for, in the latter case, the mains, it will be seen, have to carry the sum of the separate currents for each device. On the other hand, the pressure or electromotive force in series connection is the sum of all of the separate pressures or electromotive forces required for each device; in parallel connection, however, each device is subjected to one and, approximately, the same pressure or electromotive force.

It follows from the above that the series system of electrical distribution is primarily one of large electromotive force while, in comparison, the parallel system is one of small electromotive force. In the series system, aside from high electromotive force dangerous to life and the practical conditions met in its generations, there is a necessity for superior insulation and a liability to damage to the apparatus in circuit from the extra current when the circuit is broken; above all, the operation of such a system is entirely dependent upon each device in it, a broken circuit at one device throwing all out of operation, unless some kind of automatic bypass is employed. The use of the series system is, therefore, limited, being confined almost entirely to arc lighting and to incandescent street lighting.

In the parallel system, on the contrary, it will be seen by reference to Fig. 3 that any device may be cut in or out without in any manner interfering with the others in circuit. The parallel system, in fact, may be considered one in which each device in circuit has its own individual connection with the generator, the different electric conductors in practice being "bunched" for convenience. This is shown in Fig. 4 for both an electric circuit and for its hydraulic analogue. Though the subject of drop in parallel systems will be taken up later, it will here be remarked that in order that each device shall be subjected to the same potential without intermediate feeders, the main conductors will have to be conical and the system a loop one, as shown in Fig. 5.

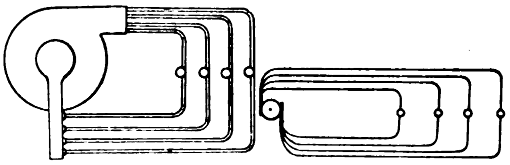
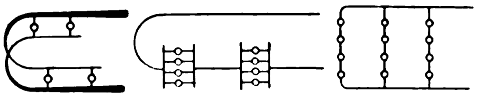


FIG. 4.

In the earlier days of electric lighting the two above systems were sometimes combined to form a series-parallel system Fig. (6) or a parallel-series system (Fig. 7). The series-parallel system is now prohibited by underwriters' rules for employment indoors. Parallel-series lighting is used in connection with incandescent and street railway parallel systems—for two arc lamps in series on incandescent circuits, or ten lamps in series on a street railway circuit; it is also used with incandescent lamps in electric railway car lighting. The three wire and various loop systems of distribution will be taken up later. In the next article the subject of Ohm's law will be taken up and its practical application explained with reference to the three different forms in which it may be expressed.



FIGS. 5, 6, 7.

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Electrical Catechism.

Are many dynamos regulated by changing the number of magnetic lines of force through the armature?

Yes. All constant potential or incandescent lighting dynamos and some constant current or arc lighting dynamos regulate by this method.

What different ways are there for changing the number af magnetic lines of force through the armature?

Either the total number of magnetic lines (the total amount of magnetism) may be changed, or the useful proportion of the total number may be changed.

How can the useful proportion of the whole amount of magnetism be changed?

By providing another path beside the armature. (See 136, 137, 146 and 147, *Electrical Industries*, December, 1895, page 339.) Some small machines have a movable soft iron bar that may be placed so as to deflect more or less of the magnetism and conduct it from one pole to the other without passing through the armature. This is an unusual method and used only for small medical machines.

Another plan once used in an English arc lighting machine was to have a double magnetic circuit, one of which furnished the magnetic field, while the other shunted more or less around the armature. The shunting part was surrounded by coils of wire through which an adjustable current passed. This plan is no longer used.

What different ways are there for varying the total amount of magnetism?

The number of lines of force in a magnetic circuit is proportional to the product of the number of turns of wire by the amount of current in the magnetizing coil and is inversely proportional to the reluctance of the magnetic circuit. Any one of the three may be varied.

What is meant by reluctance?

The reluctance of a magnetic circuit corresponds with the resistance of an electric circuit. The reluctance is proportional to the length of the circuit; it is inversely proportional to the area of cross section and also to the permeability of the circuit.

What is meant by permeability?

Permeability is the conductivity for magnetic lines of force. In other words, it is a measure of the ease with which magnetism passes through any substance. The permeability of good soft wrought iron is sometimes 3000 times that of air, varying with the quality of the iron. It also becomes less as the intensity of the magnetism increases. The permeability of cast iron and cast steel is from 50 to 800 times that of air. Some cast steel is nearly as good as wrought iron.

Can the reluctance of a dynamo be changed while the machine is running?

In a few small machines, parts of the iron field circuit are movable so as to lengthen or shorten the "air gap."

What is the air gap?

A name given to the part of the magnetic circuit composed of air. Usually the air gap is between the pole pieces and the iron core of the armature. More or less air gap is necessary to provide room for the armature wires and also for mechanical clearance between armature and pole pieces.

How can the amount of current in the magnetizing coil be varied?

In shunt wound machines this may be varied by changing the resistance in the rheostat. (See 174 in *Electrical Industries*, March, 1896, page 76.) With series wound machines (No. 165, page 76) an adjustable resistance is sometimes shunted around the series field coil so that the field may be weakened by allowing more or less current to pass around the coil. The Brush arc dynamo regulates in this way. By reducing the resistance in the shunt, less current goes through the field coils so that the magnetic field becomes weaker and consequently the E. M. F. of the armature reduced.

A Biographical History of Electricity.—I.

Whether Hoang-ti, the mythical founder of the Chinese Empire, was, in 2634 B. C., the first to construct a magnetic compass; or that such an apparatus was not invented until 1110 B. C., by Ki-tan, a Chinese minister of state; or that this invention must be placed at a later date—it may, nevertheless, be accepted that to the Chinese belongs the honor of having made the first application of magmetism to a practical purpose, as well as having devised the first practical methods of inducing magnetism in iron and steel.

Whether Thales of Miletus, one of the Seven Wise Men of Greece, who lived 600 B. C., was the first to observe the electrical effect produced when amber is rubbed with a non-conducting substance, or that this knowledge is of an earlier date, the fact remains that no practical consequences came from the discovery for more than twenty centuries. It was not until after the systems of reasoning which the Greek successors of Thales imposed for so many ages upon the intellect of Europe, began to be displaced by habits of thought which recognized nature herself as teacher and no longer rested content with the mere dicta of authority, that electricity passed beyond the stage of metaphysical speculation and entered that of physical investigation.

AM. ELECTRICIAN.

WILLIAM GILBERT, OF COLCHESTER.

There is one exception to this statement, for physicians, the only representatives of practical science in the days of Greece and Rome, seem to have applied electricity to their uses. We read that Galen and other physicians referred to the therapeutical value of the electric shock from the torpedo fish, which was considered efficacious in the cure of gout, inveterate pains in the head, etc. In this connection it is noteworthy that Gilbert, a physician, was the founder of modern electrical science, and that the discovery from which subsequently that science took its greatest impetus, was that of a physician, Galvani of Bologna.

Leaving aside the development of the mariner's compass and the beginning of knowledge in terrestrial magnetism, as well as consideration of the curious occult views held in different ages concerning amber and the lodestone, the first great name, in point of time, that occurs, is that of William Gilbert, of Colchester, called by Poggendorf, the "Galileo of Electricity" and named by Priestly the "Father of Electricity," and who, besides, shares honors with Bacon as the father of modern scientific methods.

William Gilbert was born in Colchester, England, in 1540, and received the highest education that his times afforded, having been graduated from Cambridge, of which institution he became a fellow, and is thought to have also pursued studies in schools on the Continent. Adopting medicine as a profession, he became president of the Royal College of Physicians and a physician to Queen Elizabeth, which enlightened ruler also showed her appreciation of Gilbert's learning by bestowing a pension wherewith to aid his philosophical researches.

The contributions of Gilbert to electrical knowledge are contained in his greatest work, entitled "De Magnete," written in Latin and published at London in 1600. This, the first treatise on physical science that departed from Aristotelian methods had, according to Mottelay, great influence at the time, and two editions of the book were printed at Stettin, Germany, one in 1628 and the other in 1633. It was not until within a few years that the work was translated into English and then by an American, Mr. P. F. Mottelay. The book bearing the imprint of the American publishers, Messrs. John Wiley & Sons, was published in 1893.

Up to the time of Gilbert, but two substances, amber and jet, were thought to be capable of electrification, and their attractive properties were but vaguely differentiated from those of the loadstone. Gilbert experimentally proved that a long list of substances possess the electrical properties of amber, and showed that "A lodestone attracts only magnetic bodies; electrics attract everything. * * * The distinction between electric and magnetic bodies is this: All magnetic bodies come together by their joint forces; electric bodies attract the electric only." He also considered the manner in which the attractive power of the former is influenced by moisture and heat, inventing the first electrical instrument, a crude form of electroscope, to carry out his investigations. From the term "electric" thus used by Gilbert, the word "electricity" and its derivatives have originated.

Gilbert asserts that electrics always attract and never repel, which brings up the thought that if he had as exhaustively experimented with their phenomena as he did with those of magnets, the science of electricity proper might have also received a wonderful advancement. As it is, the relatively few experiments he made led to the important conclusion that the attractive property of electrics is distinct from their substance, in this respect differing from all previous authorities.

It was to magnetism that Gilbert devoted almost exclusive attention, and for its study invented the first experimental magnetic instrument, a simple though effective device for demonstrating that the magnetic properties of the earth are identical with those of a spherical lodestone. He thus showed that the earth acts as a great spherical magnet and thereby accounted for the orientation of the magnetic needle and its dip. When he came, however, to explain the cause of the earth thus acting as a magnet, he wrongly assumed that its inner material consists of magnetic matter, from which the lodestone is produced when portions of this matter are "transformed into metallic stone."

He demonstrated that the attractive powers of a magnet can be affected only by a screen of magnetic metal, while, with respect to electrics, action is hindered by the interposition of any body—a sheet of paper or linen cloth "chokes its powers." He established that while the attraction of an electric was directed from a center, that of a magnet proceeded from the poles—in other words, that an electrified body does not possess polarity. He tested numerous kinds of iron and found that the best iron made the best magnet. He discovered that if a magnet is separated into parts, each part becomes a magnet, and if these are then reassembled "their joint force is one, nor have they separate poles;" that a piece of iron (steel?) if hammered when in the magnetic meridian becomes a magnet, and in general assumes a polarity "from the direction in which it lies while being stretched, or hammered or pulled," or "according to its position during heating and cooling;" that consequent poles may be given to a magnet; that a lodestone packed in iron filings lasts longer—this observation containing the principle of the "keeper" of the present forms of magnets. Scores of other experimental results are given throughout the pages of "De Magnete," and while the correct interpretation is not always applied, the reader is none the less impressed with the great intellectual power and experimental skill of this first "scientist" in the modern acceptance of the term.

In his experiments with magnetism and electricity Gilbert is said to have expended $25,000, a sum perhaps equivalent to over $200,000 at the present day—an expenditure the more notable from the fact that at the period when it was made the direct questioning of nature was regarded as a lowering of intellectual dignity.

That Gilbert's work should so soon have dropped out of sight may have been due to one of several reasons, or more probably to all combined. The innovation which the experimental and inductive methods involved must undoubtedly have seemed strange to the philosophers of the period, accustomed as they were to dealing with syllogisms rather than with facts. Most of these, says Gilbert, "are indolent and untrained, add nothing to knowledge by their writings and are blind to the things that might throw light upon their reasonings." Some of the main deductions of the book and those most likely to attract criticism—for example, that the earth's diurnal motion is due to magnetic causes, and that "the earth, by reason of the same potencies, lies ever in the same direction in the universe"—were doubtless early recognized as fallacies and resulted in discrediting the other contents. The views contained concerning the variation of the magnetic compass were incorrect, being based upon the assumption that such variations were due to "inequality among the earth's elevations." Perhaps of greatest adverse effect was the attitude toward Gilbert of Bacon, whose authority so long predominated in the realm of thought. He describes Gilbert's work as "an attempt to raise a general system on the magnet, an endeavor to build a ship out of materials not sufficient to make the rowing pins of a boat." The modern opinion which has done justice to Gilbert has been adverse to his great detractor, whose scientific methods, Dr. Lodge says, "are the ideas of a brilliant man of letters, writing in an age when scientific research was almost unknown, about a subject in which he was an amateur."

As a writer Gilbert is at times more lively than would be considered appropriate at the present day, constantly indulging in personalities and exhibitions of ill temper that would be rather out of place in a modern scientific treatise. He has little patience with previous writers on the subjects of which he treats, though in most cases there is abundant reason for the contempt which he expresses for them. He refers to some philosophers as sending forth, like publishers, "ancient things dressed with new names and tricked in an apparel of new words as in prostitutes' finery." Certain writers of his generation are declared to deal "only in words that involve in thicker darkness subject matter; they treat the subject esoterically, miracle-mongeringly, abstrusely, reconditely, mystically;" their philosophy "rests simply on a few Greek or unusual terms—just as our barbers toss off a few Latin words in the hearing of the ignorant rabble, and thus win reputation." One authority is accused of "sorry trifling, no better than wives' gossip." A height of indignation is reached, however, in a chapter on a magnetic perpetual motion machine, which concludes with the objurgation, "May the gods damn all such sham, pilfered, distorted works, which do but muddle the minds of the students!" One more passage will be quoted, which contains an arraignment of men and methods which has some bearing even at the present day: "Men are deplorably ignorant with respect to natural things, and modern philosophers, as though dreaming in the darkness, must be aroused and taught the uses of things, the dealing with things; they must be made to quit the sort of learning that comes only from books, and that rests only on vain arguments from probability and upon conjectures."

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The Earth as a Ground Return.

There is a great misconception, says Dr. Louis Bell, regarding the conducting power of the earth. In some recent experiments, one ground plate was placed in a well and another imbedded in a mass of filings 3000 ft. distant and the resistance of the ground circuit measured, which was found to be 66.8 ohms between the plates.

QUERIES AND ANSWERS

What is meant by the variation of the resistance of carbon under pressure? W. D. S.

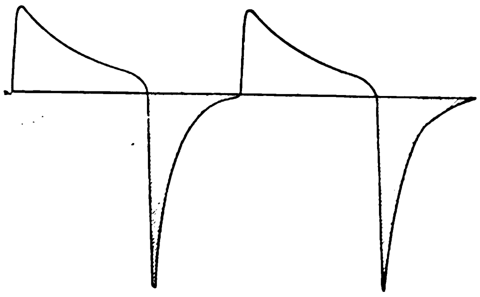
If a carbon rod has a pressure applied between its two ends, the resistance of the rod becomes greater or less as the pressure is decreased or increased. Carbon rheostats have been constructed on this principle.

What is a choking coil? W. D. S.

If an alternating current passes through a coil of wire, a back electromotive force is created in that coil, which is vastly increased if the coil has an iron core. Introducing such a coil into an alternating current circuit is similar to introducing a resistance in a continuous current circuit, except that the former entails but little loss of energy compared with the latter. A "choking" coil is properly an inductance coil, or simply an inductance; the first name comes from the action of such a coil in choking or throttling an alternating current.

Do all induction coils give an alternating current in the secondary? If so, which terminal is the cathode as spoken of in descriptions of Röntgen ray experiments? W. D. S.

All induction coils give alternating currents, but with a make-and-break primary circuit, the secondary current, when represented in curve form, is unsymmetrical, as shown in the accompanying diagram. The secondary electromotive force is much greater at "break" than at "make," as also represented by the same diagram, and thus gives a much larger spark in the former case; ordinarily when a tube is working, only the break current passes, the make current being too weak. The "break" or sparking current thus always travels in the same direction, so that one of the secondary binding posts is actually an anode, and the other a cathode, connection.



How many standard secondary cells would it take to supply a 500 ampere current at a pressure of 500 volts during five hours? E. J. B.

Assume for an instant a 150 ampere-hour cell discharging at the rate of thirty amperes, as a standard. Then, as the voltage of each cell is two volts, on a 500 volt circuit, there will have to be 250 cells in series; moreover, as each cell should not discharge at a rate greater than thirty amperes, for a total discharge of 500 amperes, there will be required seventeen series of 250 cells each, or 4250 cells in all. In point of fact, the "standard" secondary cell is a thing of the past, the sizes of cells with respect to discharge rate and watt capacity being fixed by the conditions of each installation, within commercial limits, of course. In the above case, for example, 250 cells having each a discharge rate of 500 amperes for five hours would most probably be used.

In taking Röntgen pictures, is there any advantage in having the apparatus in a dark room? H. C. J.

Röntgen rays are generated in a vacuum tube whether the tube is in the light or dark. As the plate holder is closed by an ebonite slide through which light will not pass unless it is very intense—in which case, besides, very considerable time would be required—under ordinary circumstances it is a matter of indifference whether the room in which radiographs are taken is lighted or not.

What sizes of wire and number of turns are required for the primary and secondary of an induction coil to give a three inch spark. Also, what voltage of battery is required to produce the same. H. C. J.

Directions for making a three inch induction coil are given in another column. It is best to determine the exact size of battery by experiment, adding cells until a limit is reached which is indicated by the required length of spark, or heating of the coils, or sparking in the turns of the secondary. Directions, moreover, would have to be different for every type and size of cell and for primary coils of different resistance, being dependent upon the resistance of the primary and the internal resistance and E. M. F. of the cells.

What causes the edges of commutator segments to become eaten away on a 110 volt dynamo, the commutator connections being good? A. L.

It happens sometimes, especially with some particular forms of commutator, that in securing a commutator in place on the dynamo shaft, it becomes distorted, or, rather, the segments are tilted forward or backward from a true radial position. In this case the surface of the commutator is "stepped" instead of being truly cylindrical; the wear thus comes on one edge only, and is usually much increased through sparking entailed by the "steps." It has been noticed that the edges of commutator segments sometimes become thus affected even after long use, in this case the trouble being ascribed to the segments settling. Segments from old commutators sometimes show from the wear of their brush surface that they have been running considerably out of radial position. The remedy is to set up on the retaining rings and turn down the commutator.

What is the rule for calculating the "volts lost" or drop of an electrical circuit? S. B. F.

The drop results from the resistance which is offered by any conductor to the passage of an electrical current, which resistance requires force or volts to overcome it. If the resistance of a circuit or any portion of it is one ohm, then when ten amperes are passing the drop will be 1 × 10 = 10 volts. The drop in a mile of No. 6 copper wire (2.1 ohms per mile) carrying ten amperes would be 2.1 × 10 = 21 volts. In other words, the drop of a whole circuit or of any part of a circuit is the product of the current flowing and the resistance of the circuit or the resistance of any part; or, drop = C R. In practice drops are usually spoken of as percentages, a five per cent drop on a 110 volt circuit being 5½ volts if one ampere is flowing. Drop or wiring tables are used in most cases in laying out circuits, thus doing away with calculations.

NEW APPLIANCES.

TROLLEY OVERHEAD FITTINGS.

The adjustable insulated crossover illustrated herewith has been especially designed for heavy service and durability, without, however, the addition of unnecessary weight. The center casting is so designed as to combine the supporting lugs for the insulating runs, with an extension upward on both sides of the main insulator, thus adding strength and insuring protection from the trolley pole. The movable center piece or pivot not only enables this type of crossover to be easily taken apart for installation, but also permits a free oscillating movement of the two parts, thus giving free play to the swaying or side motions of the trolley wire and preventing the breakage of the wires at the ends. The crossover can be applied to the wires in place in a few minutes and without bending, cutting or soldering. The wires are held tight in place by means of special eccentric blocks and bolts, thus preventing any tendency of the crossover to creep in the direction of travel.

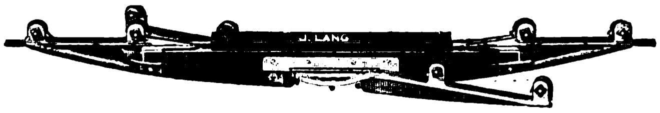


FIG. 1.

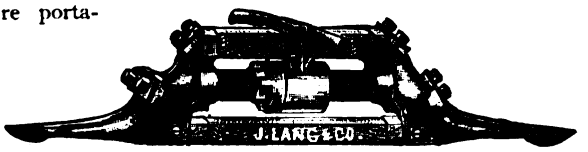


FIG. 2.

The trolley line section insulator, also shown herewith, has a straight under-run and strong clamps for fastening the trolley wires without soldering. The insulators, which are thoroughly tested for strength before being sent to the stock room, will withstand a strain of 2000 lbs. without injury. Both the above fittings are made by J. Lang & Company, 44 Michigan Street, Chicago, and have already entered into large use, the North and West Street Railway Companies, of Chicago, alone having many hundreds in use.

ECLIPSE ELECTRIC LAMP.

The electric lamp we illustrate is intended more particularly as a portable light for bicycles, carriages, etc., though it is, of course, adapted for any use where portability is a requisite. The case shown combines lamp and battery and the method of recharging the latter is made plain by the accompanying cuts. The charge is contained in a small tin box, and is diluted with water when used. The lamp is lighted when the case is in a normal position and extinguished by turning it around. This compact battery lamp is manufactured by the Eclipse Electric Lamp Company, Buffalo, N. Y.

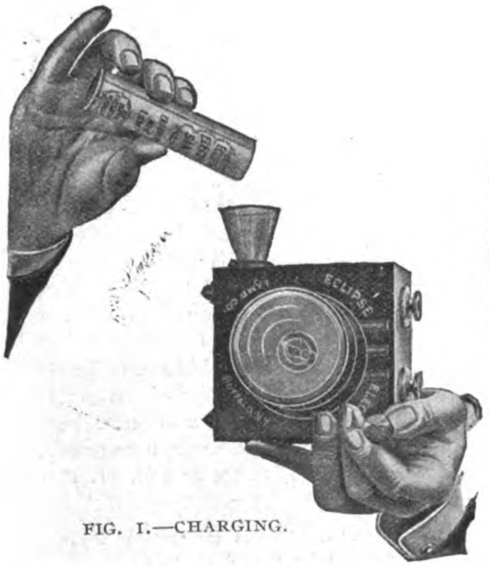


FIG. 1.—CHARGING.

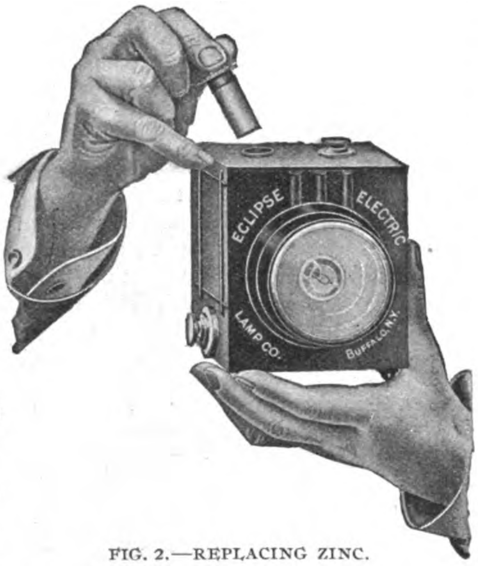


FIG. 2.—REPLACING ZINC.

THE BULLARD TRANSFORMER.

A new transformer which we illustrate herewith, now being placed on the market, is claimed by the manufacturers to embody the very latest knowledge not only in mechanical construction, but also with respect to all the requirements necessary to attain a high degree of economy in practical working. The transformer is shown in Fig. 1, in its case ready for installation. In Fig. 2 is shown the general arrangement of the coil ready to be placed in the case. Before the coils are finally taped, they are saturated and boiled in a compound of high insulating qualities and then baked into a solid mass by being subjected several days to a high temperature. All insulation used about the case is of mica. The coil is not bolted or screwed into the case, the design being such that the cover when bolted on holds it in a firm and rigid position.

Prof. Henry S. Carhart has reported as the results of a recent test on a twenty-light or 1000-watt transformer, that its efficiency at full load was 95.18 and at one-quarter load 91.66, the drop being but 2.52 per cent at full load and falling to 1.27 per cent at half load. The loss found with an open secondary was 33.6 watts and the rise in temperature after more than one hour at full load was only twenty-one degs. F. The Bullard transformer is manufactured by the Bullard Electric Company, Monadnock Block, Chicago, Ill.

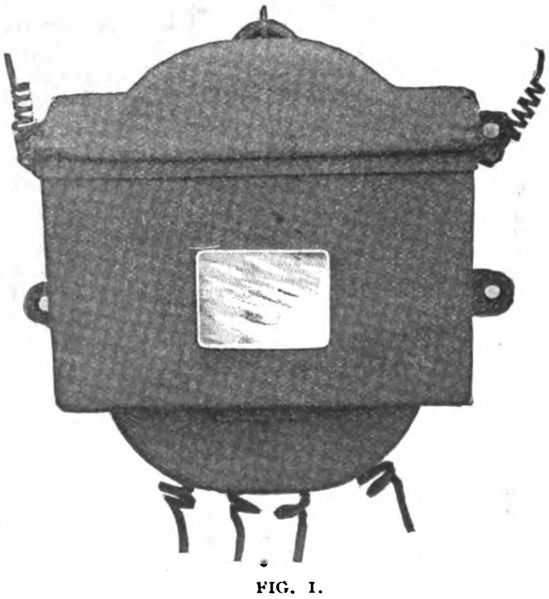


FIG. 1.

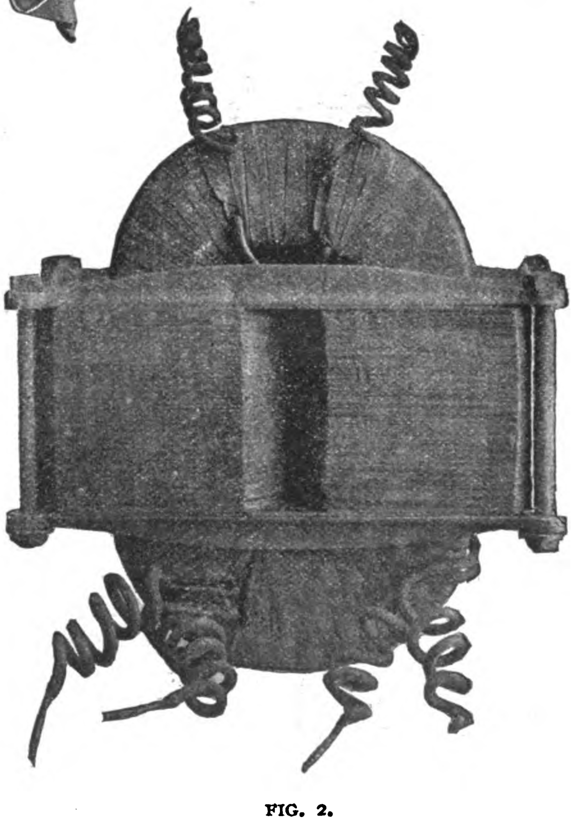


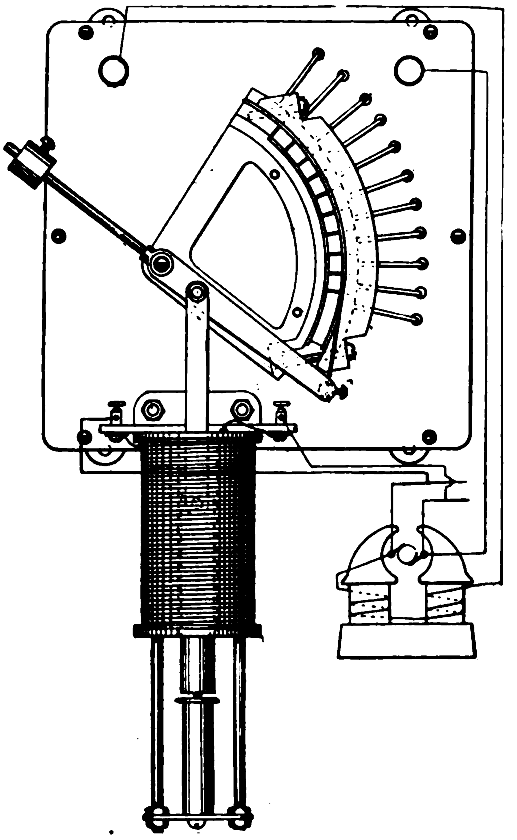
FIG. 2.

THE BELKNAP-CHAPMAN VOLTAGE REGULATOR.

That perfect automatic regulation of voltage cannot be secured at the terminals of a dynamo is, of course, well known, and therefore the desirability of a simple attachment that will enable a constant voltage to be maintained on a line is evident, particularly in connection with water power plants and where high efficiency incandescent lamps are used. The regulator which we illustrate has been designed by W. H. Chapman for this purpose, having been originated for use in connection with a water power plant where the speed of the dynamo sometimes varied from 900 to 1400 r. p. m., even when no change was made at the water wheel gate. By means of this regulator the voltage of this plant, we are informed, is now kept within 1½ volts on a 110 volt circuit.

The device consists essentially of a field rheostat operated by a solenoid. As will be seen by reference to the illustration, the solenoid core operates the arm of a lever carrying a stud and contact brush, which latter moves over the segments connected with the coils of the field rheostat. The other arm of the lever carries a weight which may be adjusted for any voltage which it is desired the regulator shall maintain. The resistance is connected into the shunt field circuit, and the connection of its coils to the segments is such that the contact brush short circuits more or less of these according to its position.

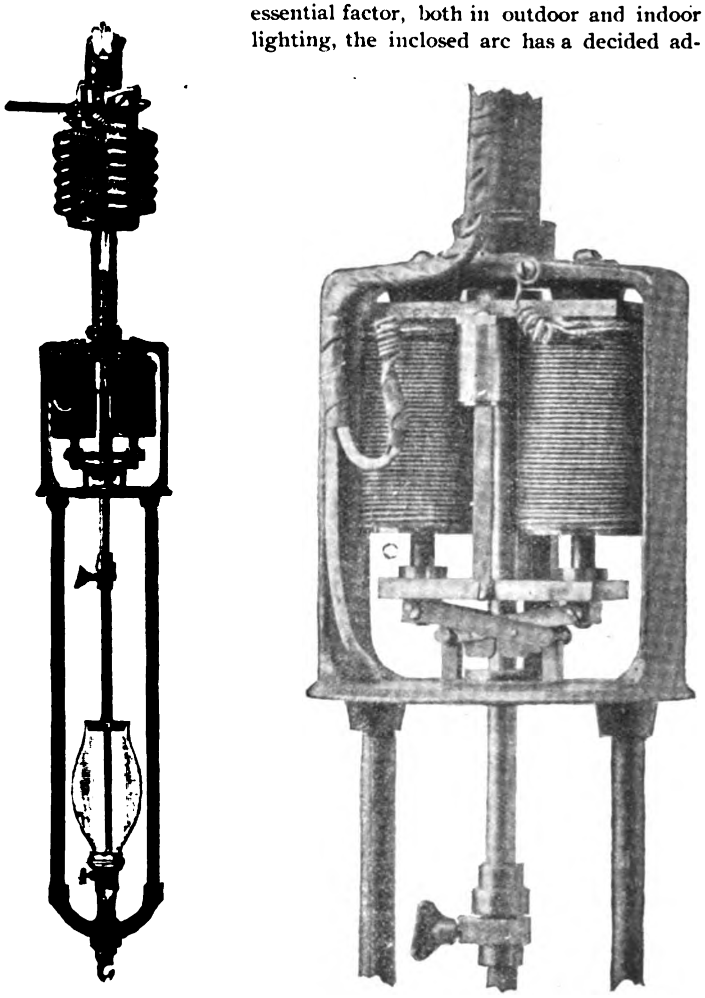
The solenoid is ordinarily in shunt with the armature circuit, but may be connected to pressure wires leading to some distant point of the system where it is desired to have the voltage kept most constant. The solenoid is built large so as to make the friction of its moving parts a small factor of the total power; it is of such proportions that the lifting force through a range of a couple of inches is almost exactly constant. A solenoid constructed to expend fifty-five watts is found sufficient to operate a field rheostat of the kind shown so as to keep changes of voltage within two per cent. Larger solenoids operate with still greater accuracy. This regulator is made by the Belknap Motor Company, of Portland, Me.



VOLTAGE REGULATOR.

INCLOSED ARC LIGHT FOR INCANDESCENT CIRCUITS.

The "Pioneer" arc lamp shown herewith is of the enclosed arc type, one of the great advantages of which is that, owing to the arc being continuously surrounded by a vapor of carbon oxide gases, a lamp will burn a hundred hours or more without change of carbons. Mr. L. B. Marks, who is well known in connection with this form of arc lamp, has introduced into the "Pioneer" a number of improvements, the success of which is demonstrated by a recent order after a competitive trial, of nearly 1000 for use in the new Siegel-Cooper department store in New York.



FIGS. 1 AND 2.—"PIONEER" ARC LAMP.

Fig. 1 shows a lamp with the globe and case removed, and Fig. 2 is an enlarged view of the mechanism. The latter, as will be seen, is very simple in character, consisting merely of a pair of solenoids actuating the clutch mechanism, no springs or auxiliary mechanism of any kind being employed.

The features of the "Pioneer" lamp for which special claims are made are as follows: The lamps require trimming at intervals of only ten days or two weeks, while in some situations with short hours of burning a monthly trimming only would be necessary. The lamp does not require cored carbons, the ordinary solid carbons being used. This results not only in a saving in the cost of carbons, but also in that of trimming—items which, together, aggregate a saving of from $15 to $20 per year per lamp. Owing to the arc being inclosed, it is possible to run the lamp on incandescent circuits at a much higher potential than where the arc is not inclosed, so that the "Pioneer" lamp can be run singly, each lamp independent of the other. It follows from this also, that one lamp cannot rob the other of light, as is frequently the case where two are run in series.

Not the least important advantage of the inclosed arc is its perfect cleanliness, since all the carbon dust is completely consumed, and, above all, its perfect qualities as a spark arrester. This has an important bearing on the insurance question, and the lamp on this account has been thoroughly indorsed by the fire underwriters.

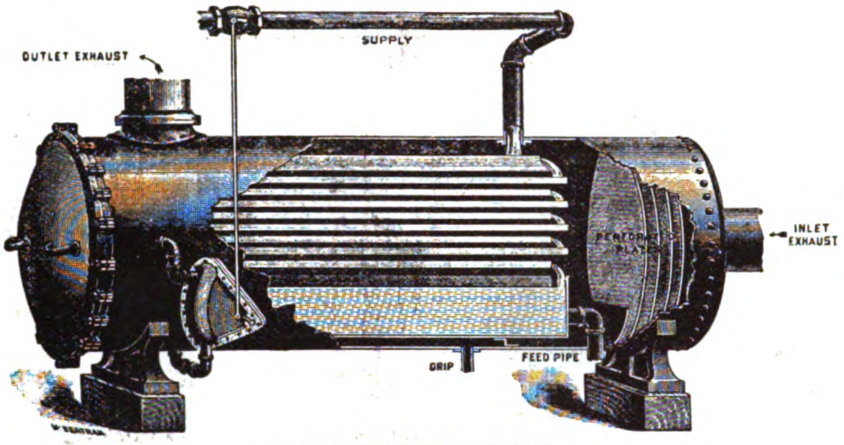
As regards distribution of light, which is an essential factor, both in outdoor and indoor lighting, the inclosed arc has a decided advantage over the open air arc. The globe of the latter always contains zones of shadow, while with the inclosed arc the entire surface of the globe is brilliant, absolutely no shadows being observable. The "Pioneer" lamp is manufactured by the Electric Arc Light Company, 687 Broadway, New York.

"STEAM JACKET" OPEN FEEDWATER HEATER.

The special points claimed for the feedwater heater shown in the accompanying cut are, first, an oil separator which consists of a series of perforated plates through which the exhaust steam passes, whereby entrained oil is very efficiently eliminated; and second, the reservoir surrounded by steam, by means of which the full temperature acquired by the feedwater in its passage over the shelves is maintained. Ordinarily in open heaters the steam simply comes in contact with the surface of the water in the reservoir, which not only reduces the heating efficiency of the apparatus, but also exposes the water to radiation through the shell of the heater.

The outside float is so arranged as to be easily accessible in all of its parts in case of derangement. The movable head is made light but strong, and is fitted with hinged bolts. The gasket is made of moulded rubber stretched across a boss on the heater ring, where it remains when the head is removed, and can be re-used indefinitely. Any ordinary head can be taken off and replaced in five minutes. The pans are made of steel, light but strong, and easily removable for cleaning, as is also the bottom reservoir if necessary.

This heater, which is made by Wm. Baragwanath & Son, 55 West Division Street, Chicago, is designed to meet the demand for an efficient, low-priced open heater with the best possible arrangement for accessibility for cleaning and the most improved arrangement for removing the oil.



OPEN FEED-WATER HEATER.

THE WHEELOCK CONSTANT-CURRENT BATTERY.

The battery shown complete and in detail in the accompanying illustrations, is of the closed-circuit, constant-current type, and especially adapted for electroplating on a small scale, for running fan motors, dental tools, sewing machines, phonographs, etc,, and also admirably suited for operating induction coils, such, for example, as those employed in Röntgen ray experiments. The zincs rest in a trough containing mercury, and are thus automatically kept amalgamated as in the Fuller battery. The solutions are of cheap materials, sulphuric acid and chromic salts, and the flat zincs used are easily obtained, while the jars are of the ordinary pattern. The makers state that the capacity of a 6 in. × 8 in. cell for one charging is 200 watt hours and the discharge rate from two to fifteen amperes. Other sizes having a discharging rate as high as 100 amperes are made. The low resistance of the cell is largely due to the arrangement of the carbons in the form of an inverted T in the porous cup, by which a comparatively small amount of carbon surface produces results usually requiring a very large surface. The nature of the specially treated porous cup, together with advantageous combination and proportion in the solutions used, also conduce to this result. The simplicity of the mechanical parts of this battery are such as to make it both handy and economical to charge and renew. The Wheelock battery is made by J. H. Bunnell & Company, 76 Cortlandt Street, New York.

WHEELOCK BATTERY.

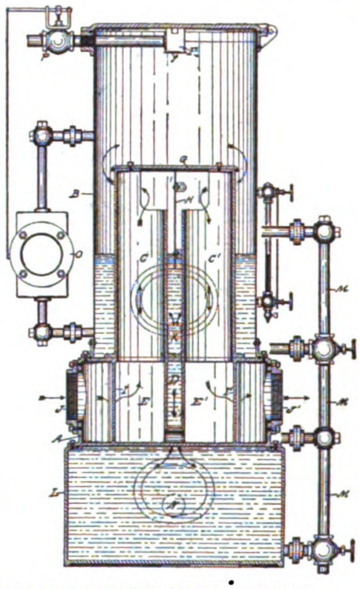
THE COOKSON HEATER, PURIFIER, FILTER AND OIL SEPARATOR.

The accompanying engraving is a sectional view of a combined feedwater heater, purifier, filter and oil separator, and illustrates the construction and operation of the apparatus. By referring to the letters and arrows, the respective courses of the steam and water may be easily traced through the heater.

The exhaust steam enters on the left at J, where it strikes the baffle plate, I; the oil and the water there condensed run down the corrugated surface of the plate, and the oil finally drained through the pipe M, shown on the right. The steam then passes around either side of the baffle plate and enters a chamber, E, whence it passes up through the pipe C, to the upper chamber B, and in this latter chamber strikes a spray of feedwater entering through the inlet F. The steam remaining uncondensed continues its course around the table G, down through C^{I} into E^{I}, where it strikes the baffle plate I^{I}, which operates to still further purify and dry the steam. Finally, passing around this latter plate, the steam escapes through the outlet on the right, J^{I}.

As noted above, the feedwater is sprayed into the chamber B, through the inlet F, where it comes into contact with the steam; it then falls upon the table G, and spreads out and runs over its edges, when it again encounters the ascending and descending steam, being thereby thoroughly heated. The water thus heated and purified in chamber B, then passes down through the pipe K, between the partitions forming the chamber, D, into the settling or filtering chamber L, whence it is drawn off at N. Thus it will be seen that the water is first thoroughly heated by the steam in the upper portion of the chamber B, then settles into the lower portion, where it is further heated by coming in contact with the pipes C, C^{I}, the impurities thereby being removed by settling and flowing off. The water then enters the compartment D, where it is heated to a high temperature by the steam on both sides of it.

It will be noted that the table G, extends beyond the surface of the pipes C, C^{1}, this being in order to prevent water from running down the surfaces of the latter, which are also cut away from their center towards the center of the heater to facilitate the escape of the steam and to further prevent water from running down. The filtering chamber L, may be filled with Excelsior shavings or other filtering substances to remove any remaining impurities from the water. The impurities precipitated in the different chambers are removed by blowing off or through manholes provided for that purpose. This combined heater, purifier and separator is manufactured by the Bates Machine Company, of Joliet, Ill.

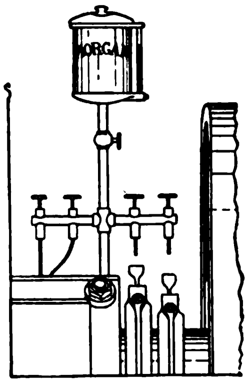


COOKSON FEED-WATER HEATER.

THE MORGAN LUBRICATOR.

The oil reservoir of the lubricator illustrated herewith is of a size to hold a sufficient supply of oil for the entire machine which it serves, and on which it is supported at a sufficient elevation to allow the oil to reach all wearing parts by gravity. The tank has a glass gauge on the side to show the height of oil in the tank, and at the bottom is a trap to collect whatever water may find its way into the tank. A wire strainer within the tank collects particles of lint or other matter liable to clog the oil passages.

The supply of oil is distributed from the reservoir through a main feed pipe, from which branches extend, carrying specially constructed oil nozzles. The nozzles consist of two parts, each of which is provided with a threaded tip adapted to a registered opening in the upper and lower sides of the tube. Through the upper member passes a tubular valve stem with a small hand wheel on the upper end. When turned down the lower end rests in a seat on the upper end of the lower member, closing the opening and preventing the oil passing into the nozzle. The space in the pipe around the valve stem permits the oil to pass to other nozzles beyond, should a branch supply more than one. The amount of oil passing through the nozzle is regulated by this valve, and may be observed through the windows in the lower chamber of the nozzle. These windows are covered by an interlining of mica.

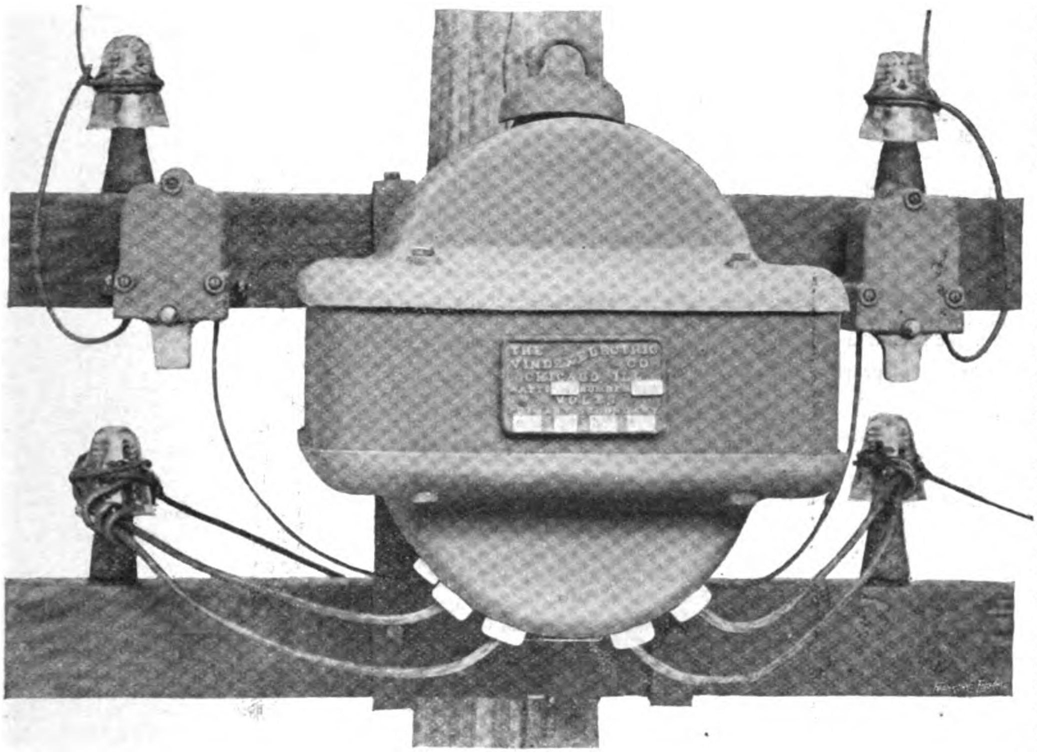


MORGAN LUBRICATOR.

The entire system is securely enclosed to prevent the entrance of dust and dirt. The strainers in the reservoir can be quickly removed for cleaning and every part of the apparatus is easily cleaned. The ends of the branch tubes are fitted with caps so that a cleaning rod may be passed through them. By removing a small plug on the top of the hand wheel, the opening through the stem is exposed and a wire may be passed through the nozzle. This work may be done at any time without it being necessary to stop the machinery. The Morgan lubricator is being manufactured for use with various classes of machinery by the inventor, J. W. Morgan, Nashville, Tenn.

THE VINDEX TRANSFORMER.

The transformer shown in the accompanying cut has been especially designed to obtain the smallest possible variation of secondary E. M. F. between no load and full load. To this end the cross section of copper has been increased, which not only improves the regulating qualities of the transformer, but also reduces the temperature of the coil, which runs at but slightly increased temperature over that of the surrounding atmosphere. It will be noticed that the coil of the transformer is very short, whereby a more efficient radiating surface is secured and the magnetizing or leakage current reduced. The iron laminæ of the core proper of the Vindex transformer have very close contact from being placed under a great pressure after building up and previous to the insertion of the coil. When the core is placed within the coil, the U shaped punchings are assembled around the coil, their ends being inserted in the openings provided in the core. The bright edges of the laminæ make good contact with the bright edges of the core, thus making each sheet practically complete in its own plane and thereby securing an efficient magnetic circuit. The coils are insulated with a special insulation which is claimed to render the coil absolutely impervious to moisture, making it possible to operate the coil with perfect safety when immersed in water.



VINDEX TRANSFORMER.

The transformer has a detached fuse box, made entirely of porcelain. By removing a pin the porcelain fuse plug may be withdrawn and the fuse replaced, or a duplicate plug reinserted. In the design of the fuse box all of the various defects that have developed with other types have been avoided, and the box has been repeatedly tested at 5000 volts, 25 amperes and a frequency of 60 with perfect success. The design is such that it may be placed either upon the face of a cross arm, on a building or upon the convex surface of a pole. The "Vindex" transformer is made by R. Ralph Lane & Company, Monadnock Block, Chicago.

NEW BOOKS.

ELECTRICAL LAW OF THE STATE OF NEW YORK. By Wendell V. R. Barnard, Albany, N. Y. Banks Brothers. 172 pages. Price $1.

A concise treatise on electrical law as existing in the state of New York, citing all of the federal and state statutes on the subject and some hundreds of cases in interpretation thereof.

WESTINGHOUSE ELECTRIC STREET CAR EQUIPMENTS. By Frederick L. Hutchinson and Leo A. Phillips. 91 pages, 40 illustrations. Price, $1.

This useful little book contains a description of the various motors, controllers and other electric street car apparatus manufactured by the Westinghouse Company, together with detail instructions for the operation, inspection and repair of the same, and directions for locating and remedying faults. To those in charge of or handling Westinghouse street railway apparatus, this book should prove invaluable, while others who may desire to know something of the practical side of electric railways will find in it much to interest them.

JOHNSTON'S ELECTRICAL AND STREET RAILWAY DIRECTORY FOR 1896. New York. The W. J. Johnston Company, 832 pages. Price $5.

This work, the only one of its kind published in this country, contains lists of electric light central stations, isolated plants, mining plants, street railways, telegraph, telephone and district messenger companies, and the names of manufacturers and dealers in electrical and street railway apparatus, machinery and supplies. The scope of the directory is not confined to the United States, but includes Canada, Mexico, Cuba, Central and South America. According to the figures given in the directory, there are now in the United States and Territories, Canada, Cuba and Mexico, 2711 electric light central stations and 1140 street railways; 828 of the street railways, with a mileage of 14,850, are operated by electricity, and 312, with a mileage of 2300, by horse, steam or cable power. The directory also publishes a list of 7150 manufacturers, dealers, electrical engineers, etc., engaged in or catering to the electrical business.

TRADE PUBLICATIONS.

Purifiers and Heaters. The Hoppes live steam feedwater purifier and exhaust steam feedwater heater forms the subject of a well illustrated catalogue bearing the imprint of the Hoppes Manufacturing Company, Springfield, O. This well known apparatus is shown in several forms, and every detail of their construction made plain by accompanying engravings.

Projectors and Search Lights. In a pamphlet issued by the Rushmore Dynamo Works, of Jersey City, N. J., a number of types of electric reflectors are illustrated and described, ranging in size from those used in the largest warships. Several full page cuts show various interiors of the Rushmore works, from which a good idea of their extent and equipment may be obtained.

Electrical Measuring Instruments. Jas. G. Biddle, Drexel Building, Philadelphia, in a circular dated April, 1896, illustrates and describes in detail the Rowland-D'Arsonval galvanometer, and another circular of the same date is devoted to a "preliminary catalogue" of electrical measuring instruments of recent design. A third circular, dated May, 1896, relates to Weston and Bristol instruments, tachometers, etc.

Lafayette Dynamos and Arc Lamps. The latest catalogue of the Lafayette Engineering & Electric Works, Lafayette, Ind., is an unusually handsome specimen of the printer's and engraver's arts. In it are described in detail the bipolar and multipolar dynamos and motors and types of arc lamps manufactured by this firm, as well as various kinds of electrical appliances. But few electrical catalogues have been executed as artistically as this handsome pamphlet.

Municipal Street Railway Problem. The Johnson-Lundell Electric Company, 29 Broad Street, New York, in a neat pamphlet describes the principles of the Johnson-Lundell electric railway system, now in operation on a portion of West Thirty-Fourth Street, New York. The description is in simple non-technical language, and refers to a surface-contact method of transmitting current to a car which is claimed to have decided advantages over both the trolley and open conduit systems for municipal service.

The K. A. K. Electric Railway System. Under this title, Messrs. Krotz, Allen & Kelly, of Springfield, O., have issued a handsome pamphlet describing a surface and subsurface system of electric traction for street and elevated railways, and for use on present steam roads. The principal feature of the system is a conduit supported, in the two latter cases, on the track ties at a distance of about six inches from the rail, or in the case of street railways, in the middle of the track, having the top flush with the top of the rails and the surface of the paving.

Lightning Arresters. In a large page pamphlet issued by the Westinghouse Electric & Manufacturing Company, Alexander Jay Wurts presents an interesting contribution to the subject of lightning discharges and lightning arresters, under the title of "Current Practice in Protecting Electrical Apparatus Against Lightning." While frankly written in the interest of the Wurts lightning arrester, much of the matter contained relates to the subject in its general aspect, such as the nature of lightning discharges, fundamental principles of lightning protection, etc. As a treatise on the protection of electric lines from lightning, this pamphlet will be of much interest and value aside from the commercial object it has in view.

A Handsome Engine Catalogue. Few dealers in or makers of objects of fine art issue handsomer catalogues than some manufacturers of electrical and mechanical apparatus, and among the latter are numbered A. L. Ide & Son, of Springfield, Ill., whose most recent catalogue of "Ideal" engines is an artistic production in every sense. This is no more than appropriate, as indicated by the title "High Art Engines," for tasteful and harmonious mechanical design is no less pleasing to the eye than that produced by the brush or chisel of the artist. In the thirty-two pages of the pamphlet more than a score of finely executed and well printed illustrations show every detail of the Ideal engine and all the various types, some of which are illustrated direct coupled to dynamos.

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EXHIBITION NOTES.

Stanley & Patterson, 32 Franklin Street, New York, show a large number of specialties in their booth, both in house and electric lighting appliances and supplies.

The Hart & Hegeman Manufacturing Company, Hartford, Conn., was represented at the Electric Light Convention by A. H. Pease and Gerald W. Hart, who have made many new friends for the company among the electrical trade.

The Joseph Dixon Crucible Company, Jersey City, N. J., has a handsome display of its various lines of manufactures, ranging from roof paint to lead pencils, crucibles and all manner of lubricants. The exhibit is in charge of John H. Baird.

The Ferracute Machine Company, Bridgeton, N. J., has several of its presses on exhibition operated by Crocker-Wheeler motors, one of which is engaged in stamping souvenirs from sheet aluminum. The exhibit is in charge of W. S. Mitchell.

The Keuffel & Esser Company, 127 Cortlandt Street, New York, has a large and well displayed exhibit of drawing materials, surveying instruments, indicator scales for steam and electrical diagrams. One case is occupied by many forms of slide rule calculators.

The Forest City Electric Company, Cleveland, O., has on exhibition samples of its roll drop and forged commutator bars, finished commutators, etc. W. B. Cleveland, president, and J. C. Dolph, Eastern representative, are in attendance making hosts of new friends among trade visitors.

A. O. Schoonmaker & Company, 158 William Street, New York, has a tastefully displayed exhibit in charge of A. O. Schoonmaker, including samples of solid sheet mica cut in segments, rings and washers, as well as samples for all the other purposes for which mica is used in electrical manufacture.

The Bradford Belting Company, of Cincinnati, O., has a display of Monarch paint and Monarch belts in a booth tastefully designed and decorated with bunting and growing plants. The exhibit is in charge of O. M. Hubbard, of Cincinnati, and Elmer P. Morris, the Eastern representative of the company.

The Washburn & Moen Manufacturing Company, 16 Cliff Street, New York, has a handsomely fitted up space occupied by wire of all kinds and all sizes. Handsome cases to the rear and to the sides of the booth are filled with coils, spools and sections of wire, artistically arranged and creating a very pleasing appearance.

The Cutter Electrical & Manufacturing Company, 1112 Sansome Street, Philadelphia, has a handsomely arranged display of its line of I. T. E. circuit breakers and C. S. flush switches, underload and overload circuit breakers for use with motors, etc. The company is represented by H. B. Cutter, A. Edward Newton, W. E. Harrington, and S. N. Nicholson.

W. Goldstein, 630 Water Street, New York, is represented at the exhibition by Albert G. Schreiber and W. Goldstein, who preside in a booth handsomely decorated in yellow and white bunting. Various large specimens of scale are shown which have been removed from boilers by the "Boiler Scale Eradicator," a compound that has a fine record.

The Peru Electric Manufacturing Company, Peru, Ind., shows neatly arranged samples of the goods of its manufacture, consisting of porcelain in all the various shapes and sizes used for electrical purposes. There is also a sample display of the original Laclede and Hercules batteries. R. H. Bouslog and J. T. Stevens, secretary and treasurer, have charge of the exhibit.

The Bi-Metallic Electric Transmission Company, Havemeyer Building, New York, has a space in the booth of the John A. Roebling's Sons Company, who are the manufacturers for the Bi-Metallic Company of its widely known bi-metallic wire for telephone and other purposes. The exhibit is in charge of Mr. Willard M. Miner, electrician of the company.

The Ball Electric Company, 407 West 27th Street, New York, is represented by one of the best known electric light men in attendance at the Exhibition, W. J. Morrison. One of the Ball new improved 100 light, 2000 c. p. dynamos and a new improved 50 light, 1200 c. p. dynamo are shown, the former unassembled, and the latter forming part of a complete station equipment.

Charles A. Schieren & Company, 45 Ferry Street, New York, has a belting exhibit which is exhaustive in its line, consisting of electric and perforated electric brands of leather belting for use in connection with dynamos, street railway generators and all kinds of high speed work. C. A. Schieren, Jr., and E. P. Atkinson are on hand, as usual, entertaining their old friends and making new ones.

The Calculagraph Company, 2 Maiden Lane, New York, has an exhibit of a number of calculating machines, one of which is combined with a telephone switchboard for keeping account of calls. Another is adapted for telegraph and district messenger service, designed to show lapse of time and value of time in dollars and cents. Henry Abbott, president, and H. Hamilton are in charge.

The E. G. Bernard Company, Troy, N. Y., shows a handsome rotary transformer in the booth of Stanley & Patterson. The machine consists of two of the well known form of Bernard machines mounted on a common base, the two armatures being on a common shaft. The combination, which is of about 2½ k. w., is much admired for both its fine mechanical execution and handsome finish.

Hugo Reisinger, 38 Beaver Street, New York, in an attractive booth decorated in white and gold makes an excellent display of "The Electra" high grade Neurnberg arc lamp carbons, Crown microphone and battery carbons, carbons for smelting anodes, etc. Visitors are presented with a handsome note book in celluloid as a souvenir. J. T. Outwater and Fred W. Nolker are in charge of the exhibit.

The Standard Paint Company, 81 John Street, New York, has a most attractive display of samples of the famous P. & B. compound, including armature and field coil varnish, insulating paint, insulating tape and paper, rubberoid roofing and preservative paints. This large exhibit is very attractively arranged and the booth decorated with national flags. F. S. De Ronde, F. F. Vandewater and J. W. Richards entertain hosts of callers.

The Standard Thermometer Company, of Peabody, Mass., has an interesting exhibit in the booth of the J. H. McEwen Manufacturing Company, consisting of various styles of arc lamps in the manufacture of one type of which—that for incandescent circuits—this firm has been a pioneer. A telemanometer attached to a steam pipe shows the manner in which steam pressure may be indicated at a distant point by means of electricity.

The Sprague Electric Elevator Company, 253 Broadway, New York has a large and prominent space facing the canal towage model, where there is installed a multiple sheave electric passenger elevator of the type which has so largely entered into use throughout the United States. There are also shown a tandem gear drum elevator, a house elevator and elevator regulators, switches and detail parts. M. B. Kett is in charge of the exhibit.

The John A. Roebling's Sons Company, Trenton, N. J., has one of the most popular booths, if the large number of visitors always present can be accepted as a criterion. In the booth, which has rather the appearance of a handsome reception parlor, are shown samples of all the numerous grades of wire made by this old established firm. Among those on hand to entertain friends are Messrs. W. L. Doyle, M. R. Cockey, E. W. Swan and A. M. Whitaker.

H. B. Coho & Company have on the ground floor an exhibit consisting of two complete generating plants. One comprises a forty kilowatt Eddy generator direct connected to an Ideal engine, the frame common to both being supported on three points without bolts or fastening of any kind. The other consists of a thirty kilowatt Eddy generator direct connected to a Watertown engine. H. B. Coho was present at the convention, and R. J. Mulligan had charge of the exhibit.

The Weston Electrical Instrument Company, Newark, N. J., has one of the most interesting exhibits in the Hall, and contains, in fact, one of the most remarkable objects there displayed—an ampere meter of 180,000 amperes capacity. Among other objects in this very neatly arranged display that attract particular attention are a number of huge shunts used in connection with ampere meters for measuring currents of very large volume. A. J. Pionnet has charge of the exhibit.

The Mica Insulation Company and Eugene Munsell & Company, 215 Water Street, New York, have a space full to overflowing of samples of their mica for every possible use to which mica can be put in the manufacture of electrical apparatus. Among the object exhibits are two large complete commutators shown insulated in skeleton, and one No. 16 Edison armature body showing mica insulation complete. C. W. Jefferson, manager, and E. C. Wood represented these companies at the Exhibition.

Huebel & Manger, 286 Graham Street, Brooklyn, N. Y., have a most comprehensive display of their line of electrical specialties, consisting of push buttons, gas lighting keys, wood and iron box bells of every description, from a small 2½ in. house bell to a fifteen inch fire alarm bell. O. H. Huebel and F. W. Manger are on the ground making many new friends among the trade visitors. W. W. McChesney, Jr., who has just returned from a most successful business trip to the Pacific Coast, is in charge of the exhibit.

The Partrick & Carter Company, 125 South Second Street, Philadelphia, have a display which stands out very prominently in the hall, and attracts much attention. They show many new specialties and it is worthy of note that all of their goods on exhibition are taken from stock, none having been specially made or furnished for the occasion. Their representatives on hand are E. Ward Wilkins and Thos. L. Townsend, whose wide acquaintance among the trade is evidenced by the numerous greetings they receive.

The Diehl Manufacturing Company, Elizabethport, N. J., were represented by G. J. Knight and C. A. Bramhall, and is fortunate in possessing among its own manufactures highly decorative features for its booth, the ceiling fans displayed admirable lending themselves to this use. A part of its exhibit, which attracted the attention of the ladies, was a sewing machine inlaid with pearl and run with one of the new Diehl balance wheel motors. The Knight arc lamp was also present in numbers, as well as an exhibit of the new Diehl multipolar dynamo.

The Gordon-Burnham Battery Company, 82 West Broadway, New York, makes a display of fine effect merely by artistically grouping in a varied manner a large number of Gordon cells and parts of cells. There are few visitors who pass this booth without stopping and examining the Gordon cell, which seems to attract the attention of all classes of visitors, both electric and lay. The fact that this battery is admirably adapted for use in making Röntgen ray experiments, adds to its interest. R. W. Gordon, vice-president, and W. C. Banks, electrician of the company, are in charge of the exhibit.

The J. H. McEwen Manufacturing Company, 26 Cortlandt Street, New York, shows on the ground floor a 10 in. × 10 in. McEwen engine and a forty kilowatt direct connected Thomson-Ryan generator. By means of a water rheostat a load may be thrown on to the latter up to fifty per cent of its capacity. An indicator is connected in order that cards may be taken at any desired load and a speed indicator attached shows fluctuations in speed. The exhibit is in charge of J. H. McEwen, president of the company, and F. G. Bolles, Eastern agent. In the same space is shown Jerome metallic packing.

The Bishop Gutta Percha Company, 422 East Twenty-fifth Street, New York, has a very interesting exhibit of wires, among which are included samples of the cable used in lighting Gedney's Channel, and a section of gutta percha conduit which has been used between New York and Blackwell's Island for over fifteen years, which well illustrates the great durability of gutta percha under water. There are also samples of every description of flexible and other electric wire, including marine wire for use in wiring men-of-war. W. W. Marks, superintendent, and H. D. Reed have charge of the exhibit.

The Simplex Interior Telephone Company, Cincinnati, O., has on exhibition an intercommunicating interior telephone, extremely small and compact in size. An idea of its efficiency may be obtained from the fact that on the opening night of the exhibition, 250 calls were forwarded from five stations in different parts of the building. This company has also a simple and efficient residence, two-station instrument, as well as a system for hotel use. Its neat device for attaching instruments to an office desk is much admired. W. L. Bradshaw, president and general manager, is in charge of the exhibit.

The Okonite Company Ltd., Postal Telegraph Building, New York, occupies a handsomely fitted space in a prominent position facing from the left on main entrance aisle. The booth is handsomely decorated with yellow bunting with the familiar Okonite trade mark prominently displayed. An interesting feature of this exhibit is a lump of fine Para rubber weighing 697½ lbs. The numerous samples of wire and cable, ranging from the smallest size to the largest in commercial use, illustrate the comprehensive extent of the manufactures of this company. The Okonite company is represented at the exhibition by Capt. W. L. Candee, Geo. T. Manson and Romaine Mace.

The Safety Insulated Wire and Cable Company has one of the striking featurss of the show, besides a display of all manner of aerial, underground, submarine wires and cables for power, electric light, telegraph and telephone service to attract attention. The electrical visitor is highly interested and the lay visitor amazed by an ingenious advertising novelty manipulated from the booth. This consists of an electric signboard upon which sentences are written, one word after another, in ordinary longhand, the letters and words standing out in light. In addition, all manner of picturesque views and portraits are thrown on the board to amuse the audience. Among representatives of the firm to be seen about the booth are H. T. Richards, L. R. Clark, Jr., Ira W. Henry, A. P. Eckert and L. F. Requa, Jr.

The Fort Wayne Electric Corporation, Fort Wayne, Ind., is represented by H. C. Adams and F. H. Leonard. The large booth occupied by this company contains representative types of Ft. Wayne machinery and apparatus, among which are several single phase alternating current motors. These latter, which formed the subject of a paper read by Mr. Leonard before the National Electric Light Convention, attracted much attention from visitors and, in fact form one of the few exhibits in the hall marking a considerable devolopment in electrical design Among other exhibits which attract particular attention are the Wood meters and Wood rotary transformers. The same company has on the ground floor a working exhibit of a six-pole twenty-five kilowatt incandescent dynamo direct connected to a Woodbury engine running at 300 r. p. m.

The Interior Conduit & Insulation Company, 527 West Thirty-fourth Street, New York, occupies one of the largest spaces in the hall, facing the model of the Niagara Falls power plant. Among the many exhibits is a direct connected plant specially designed for marine purposes, consisting of a fifty horse power Lundell generator direct connected to a Case engine. Numerous sizes of Lundell motors may be seen, ranging from 1-12 h. p. up to 35 h. p. A Mason & Hamlin organ forms part of the exhibit, being operated by a Lundell organ-blowing outfit, and a Cottrell printing press operated by a Lundell motor furnishes another object lesson on the application of electric power. A complete line of brass armored, iron armored and unarmored insulated conduits is shown, including all forms of fittings. Other exhibits are several dental outfits run by Lundell motors, Johnson double pole switches, etc. Among the representatives of the company seen about the exhibits are: E. B. Kittle, Geo. H. Kimber and D. C. Builard.

The Stanley Electric Manufacturing Company, Pittsfield, Mass., occupies not only one of the most prominent positions in the Exhibition Hall, but has also the pleasure of seeing its exhibit recognized as one of the particular centers of attraction. Several score of articles are on exhibition in this booth, including various forms of switches, measuring instruments, and an 180 k. w. 2000 volt generator. This generator, which is of the inductor type, is admirably disposed for a thorough examination, and furnishes a commendable object lesson on the perfection to which electrical design and execution is now carried. Among other exhibits that attract particular attention are a static ground detector and several forms of switches for high tension currents. In some of these switches the spark is cut off by shutters which close behind the knife blade when it is withdrawn. Among those who have been present in the booth are Henry Hine, general manager, Wm. Stanley, Jr., John F. Kelly, W. W. Gamewell and Theodore E. Theberouth.

The Crocker-Wheeler Electric Company has an exhibit which would attract visitors none the less were it located in other than the conspicuous position it occupies, which is in the main hall and facing the Niagara model. Among the machines and parts of machines shown are several rotary transformers, a mill type of motor and controller, a 300 h. p. armature, a 112 h. p. armature for direct engine connection, an electric pump, an electric hoisting engine, an electric sensitive drill, etc. On the ground floor the same company has a 250 volt, compound wound dynamo, driven by a New York Safety engine, and in several other prominent exhibits Crocker-Wheeler motors form part of power apparatus. H. L. Lufkin and F. B. De Gress are in charge of the exhibit. On Thursday night, by invitation, a large number of the members of the National Electric Light Convention and others visited the Crocker-Wheeler factory at Ampere, N. J., where they were the guests of Dr. S. S. Wheeler, who personally showed them over these very complete works.

The Westinghouse Electric & Manufacturing Company, Pittsburgh, Pa., has an exhibit in a prominent position under the arched roof at the main entrance. A number of Tesla two phase motors are shown, and also two Tesla single phase self starting motors. Much attention is attracted by a demonstration of the principles of induction by means of very simple apparatus consisting of several coils of wire. A Shallenberger alternating current meter is shown with the case off and connected to a lamp board containing twenty-two Sawyer-Man lamps, thus giving a practical illustration of the working of the meter. The most striking exhibit of all, however, is a small two phase motor under the neighboring Niagara model, which, during the evening obtains current from the Niagara Falls power station over Western Union wires, and operates a water pump which supplies water to the turbines in the model of the Niagara Falls power plant. During the convention, C. F. Scott, W. F. Zimmerman, Lemuel Bannister, Calvert Townley, H. A. Cragin and other representatives of the company were about. E. H. Heinrichs, press agent, was also on deck during the electric light convention.

The General Electric Company's exhibit at the exposition is rather a pervading presence than a specific exhibit of its manufactures. The space occupied by the company is at the base of the south wall of the hall. It is enclosed by a pillared cornice studded on the outside with a line of special six candle power miniature yellow lamps, broken at the top of each pillar by a group of four violet lamps of the same candle power and on the inside with 240 volt, sixteen candle power, frosted lamps. Above the space against the wall is a large monogram, with the initials of the company set in different colored miniature lamps. The right of the space is occupied by a stand supporting a number of swiveled frames containing photographs of some of the important work done by the General Electric Company, such as the ninety-six ton B & O electric locomotive, the great Portland and Sacramento power transmissions and other installations of similar magnitude. To the left of the space stands an ornamental standard carrying arc lamps of the long burning, constant potential, direct and alternating incandescent and power circuit types. On the tables are a number of samples of the new line of measuring instruments for alternating circuits, some of the new alternating current fan motors and two samples of the new type H transformers. The space is enclosed with a unique railing formed of railway feeder cable supported by insulated suspensions and turnbuckles. The lamp department has an exhibit of its own in a small room to the left of the main space. The principal feature of this is a display board, on which is mounted a sample of every kind of incandescent lamp, outside the miniature category, manufactured by the company. On a stand in the center of the room are two boards, one carrying a variety of samples of candelabra, miniature and decorative lamps, the other samples of battery lamps. In this case, the smallest incandescent lamp manufactured is shown about the size of a small pea. Several of the ornamental illuminated designs gotten up by this department are used to embellish the room. Attached to the ceiling is a beautiful sun, the wall is adorned with a four leaved clover and horse shoe, and a patriotic device with the eagle surrounding the U. S. shield on which the colors are shown in small lamps. The two other designs are entitled "Mischief Brewing" and "Homeward Bound." The first represents a little witch bending over a seething pot beneath which glistens a red fire, while fays and sprites appear and disappear and a grewsome, green eyed cat glowers from beneath the witch's pointed hat. "Homeward Bound" is a full rigged ship tossing and pitching on her way through the moonlit waters, her port and starboard lights showing as she appears wafted toward the spectator. The company was represented by during the time of the convention by S. D. Greene, J. R. Lovejoy, W. L. R. Emmet, J. Kirkland, H. C. Wirt, W. Fulton, J. M. Andrews, of the Schenectady Office; Chas. T. Hughes, T. Beran, C. Gundacker, C. G. Davenport, George D. B. Greene and others from the New York Office; C. B. Davis, F. M. Kimball, Haley, Ives and Bush of the Boston Office; H. J. Buddy, of the Philadelphia Office; W. F. Hays, of Hays, of Cincinnati Office; A. E. Giles of the Atlanta office and A. D. Page M. K. Eyre and McAllister of the Lamp Works, at Harrison.

BUSINESS NEWS.

The Standard Paint Company has removed its Chicago office, of which J. C. Shainwald is manager, to 189 Fifth Avenue. The whole second floor will be occupied by offices and stock room.

E. M. Scribner, who for a considerable time has been connected with the Western Electric Company, Chicago, has entered into a responsible position with the Bryant Electric Company at its factory in Bridgeport, Conn.

E. P. Roberts, president of the Correspondence School of Technology, has been appointed by Yost & Packard, architects, as consulting engineer for the electric, hydraulic and sanitary engineering for the new Ohio State Asylum for the Insane, Massillon, O.

The Crown Woven Wire Brush Company, Salem, Mass., has had transferred to it the business of F. S. Burke, which gentleman will hereafter act as manager of the new company. The manufacture of both the Crown and Crown "K" brushes will be continued.

W. W. McChesney, Jr., has just returned from an extended trip of some two months through California and the West, in the interests of Huebel & Manger, of Brooklyn. On his trip Mr. McChesney secured some good orders and reports the business outlook as promising.

The Card Electric Company, Mansfield, O., has been awarded the contract for supplying the Ohio State Reformatory with two direct connected multipolar generators at sixty-six kilowatts each at a speed of 250 r. p. m. The generators will be direct coupled to Ball engines.

W. H. Sills & Company, Chicago, have removed their offices and factory to 59 Lake Street. This change is made necessary in order to have larger facilities for carrying on the firm's extensive mica business. All grades of mica in sheet or cut to any size are their leading specialties.

The J. H. McEwen Manufacturing Company has closed contracts for a long list of steam and electrical apparatus, comprising sixteen generators ranging from 200 k. w. to 25 k. w. capacity, mostly in larger sizes, and nineteen engines ranging from 14 × 28 × 20 tandem compound to 8 × 10 simple engines.

The Sunbeam Incandescent Lamp Company has removed its offices from 100 Washington Street, Chicago, to the Monadnock Block. The Western agencies of the Cutter Electrical & Manufacturing Company, of Philadelphia, and the Lakon Company, manufacturers of the Lakon transformer, which are in charge of F. S. Terry, have been removed to the same address.

The F. H. Cornell Company, 461 Fourteenth Street, New York, has received a very flattering testimonial from the Tuscawaras Electric Company, of Canal Dover, O., concerning the Hercules oil injector, which is stated to save the company a large amount of money over the old way of cleaning boilers, and keeps the boilers perfectly clean. The letter adds that its use saves not only expense for cleaning, but also in coal.

The Metropolitan Electric Company, Chicago, has just taken the agency for the Diehl Manufacturing Company, of Elizabethport, N. J., and will carry in stock a complete line of its ceiling fan motors. The Diehl Manufacturing Company is the oldest manufacturer in the country of ceiling fan motors in their various shapes and styles, and the Metropolitan Electric Company is fortunate in securing this agency.

The Orient Electric Company, Youngstown, O., has recently opened a Chicago office at 1628 Monadnock Block. The office is in charge of T. S. Lane, a salesman of wide experience in the electrical field. This company is manufacturing a high grade incandescent lamp, special attention being given to testing, so that the output of the company comprises the best quality. The manufacturing part is in charge of C. N. Sadler, a well known practical lamp maker.

The Sawyer-Man Electric Company. The board of directors of the Sawyer-Man Electric Company announces that this pioneer company has been reorganized, and that the manufacture of the celebrated Sawyer-Man incandescent lamps will at once be resumed. This will doubtless be welcome news to former users of the Sawyer-Man lamp, who were proverbially strong in their faith in its merits, and of scarcely less interest to every user of incandescent lamps in the country.

John Gorman, for twenty years practical electrician and dealer in electrical apparatus in St. Paul, will represent the Metropolitan Electric Company, of Chicago, in handling N. I. R. wire, Metropolitan lamps, "Mac" tape, P. & B. compound varnish, etc. Mr. Gorman is prominently identified in electrical interests in St. Paul and Minneapolis, and has done a large share of the electrical work in that section during the last twenty years. The Metropolitan Electric Company can be congratulated in getting Mr. Gorman to handle its goods.

Charles Wirt, 1028 Filbert Street, Philadelphia, has enlarged quarters and increased facilities for the manufacture of the Wirt dynamo brush. Mr. Wirt reports that he has been making radical changes in methods of manufacture, as the old methods were too slow to keep pace with increasing business and too expensive to meet competition. The Wirt brush of to day is being modified to suit different classes of machines, as it has been proved that the best combination of material for one case is not the best for every case.

Queen & Company, of Philadelphia, are to be congratulated upon the extremely creditable manner in which they have emerged from their business troubles. The assignee has turned over the business to the original company, having paid the creditors in full, and reassigned the estate with a surplus of $200,000. At a meeting of the board of directors of Queen & Company, Incorp., the following gentlemen were elected officers of the company: J. C. Gray, president, S. L. Fox, vice-president, and J. M. Hazel, secretary and treasurer.

The Armorite Interior Conduit Company, of Detroit, Mich., is now manufacturing a complete interior conduit system known as the "Armorite," which it claims is cheaper and better than any other conduit system in the market. Tubes are made in sizes from ⅜ in. inside diameter to three inches, all in ten foot lengths and lined with a prepared wood cut in semi-cylindrical section and forced into the armor, thus securing, when completed, what is claimed to be the highest insulation. Ordinary bends up to one inch conduit can be made cold on the job by the workmen.

The Sunbeam Incandescent Lamp Company, 1510 Monadnock Block, Chicago, is making a specialty of manufacturing the Sunbeam X ray tube. The tubes are all tested before leaving the factory by giving photographic or time tests. Among the photographs taken recently was that of a sparrow. When completed the photograph contained two dark spots which on inspection, proved to be shot, a fact which was not before known. The company is sending out a circular, which may be had for the asking, giving some very interesting cuts showing objects photographed with its tubes.

The Electric Arc Light Company has fitted up elegant offices at 687 and 689 Broadway, New York, and a fine laboratory at 250 and 252 Mercer Street, New York City. The "Pioneer" lamp, which is manufactured by this company, has won the confidence of several parties representing a capital of over $2,000,000 and who are now backing the Electric Arc Light Company. Vigorous proceedings, the company states, have been brought against persons using infringing lamps. A suit has recently been brought in the United States Circuit Court against a prominent firm for such infringement.

C. C. Sibley & Company, selling agents for the General Electric Company for New York City, moved its offices on May 1 from the Postal Telegraph Building to its new store at 329 Fourth Avenue between Twenty-fourth and Twenty-fifth Streets. This firm has decided that in order to better serve the trade it should keep pace with the northward march of business in New York. They will carry a full line of contractors' supplies, including interior conduit, bell and annunciator supplies. They are looking forward to a big sale of Lundell fans this season and will be prepared to fill promptly all orders for them.

The Walker Company, of Cleveland, O., has recently closed contracts for some of the most important railway equipments that have been placed for several years. Among these is a contract from the Chicago City Railway Company for six 800 k. w. generators; a contract from the Kansas City Metropolitan Street Railway Company, for a generator of 1200 k. w. capacity; and a contract from the Chicago & Englewood Railway Company for four large direct connected Walker generators for charging storage batteries, and for fifty storage battery car equipments. Among other contracts made by the Walker Company recently are for a large number of motors and complete car equipments for the following companies: Rapid Railway Company, Detroit, Mich.; Pittsburgh, Grafton & Manchester Street Railway Company, and Second Avenue Traction Company, Pittsburgh, Pa.; Newburgh (N. Y.) Electric Railway Company; Union Railway Company, New York City; C. E. Loss & Company, Chicago, Ill.

The Standard Underground Cable Company, Pittsburgh, has recently sold a large order of cable to the American Telephone & Telegraph Company, of Providence, with a guarantee of 500 megohms per mile insulation resistance and a capacity of .08 microfarad per mile. The tests of this cable by the electrician of the Providence Company disclosed a remarkably low average capacity, ranging from .076 to .0716 microfarads per mile, and showing a high degree of uniformity. The insulation resistance of the wires averaged 1933 megohms and 3300 megohms per mile respectively. The Standard Underground Cable Company has recently made a number of important changes in the personnel of its home office in Pittsburgh. P. H. W. Smith, formerly assistant superintendent of construction for the Western sales department, and more recently assistant to J. W. Marsh, vice-president and general manager, is now assistant general manager of the company. Mr. Smith's training in electrical engineering was received in Lehigh University, of which he is a graduate. He has been actively engaged with the Standard Underground Cable Company for a number of years in the construction and sales departments. F. S. Viele, formerly of the Buffalo Railway Company, but for several years past superintendent of the Western sales department and lately in charge of the latter, has been transferred to Pittsburgh as manager of the conduit and general construction department. In addition to general construction work, Mr. Viele will have under his immediate charge and supervision the conduit and rubber sales departments. Mr. Viele is a graduate of the Massachusetts Institute of Technology, and his recognized ability as a trained expert in all matters pertaining to cables makes him a valuable man to the company.

Eugene Munsell & Company, 218 Water Street, New York, have just opened a branch house at 153 Lake Street, Chicago. Chas. E. Coleman, who has been associated with the firm in New York for many years, will be in charge of this office and will visit the trade in person throughout the West. This move on the part of the firm has been made in order to accommodate Western customers and to push business in the West with more energy than hereto, fore. A complete assortment of all grades of mica for insulation will be carried in stock, as well as a full assortment of all the well known Micanite specialties manufactured by the Mica Insulator Company. Franklin Brooks, junior member of the firm of Eugene Munsell & Company, was welcomed home from his trip abroad by his many friends. The features of the tour were discussed at a dinner, which was tendered him, with greater interest than the menu. Mr. Brooks has been away some six months on a business and pleasure trip, including in his itinerary London, Paris, Monaco; then through the Mediterranean Sea and Suez Canal to India, where he spent two months in the mica fields, in which the company is largely interested. He has brought home a large number of photographs, which are very interesting and which have been procured at a great deal of expense. After having disposed of his business in the mica field, he visited Calcutta, and also spent some time in visiting China and Japan; then crossing the Pacific to Vancouver and stopping at San Francisco and Chicago before reaching New York. Mr. Brooks covered in the neighborhood of 40,000 miles in his travels. Some idea of the magnitude of the mica fields is gained from the fact that Mr. Brooks traveled about 4000 miles in that section of India alone. The firm imports mica direct from the mines and Mr. Brooks has completed arrangements whereby they are in a position to supply mica to the electrical trade in larger quantities than heretofore.

First-Class Steamboat Service between Detroit and Cleveland, and Cleveland, Put-in-Bay and Toledo.

D. & C. Floating Palaces are now running daily between Detroit and Cleveland, and between Cleveland, Put-in-Bay and Toledo. If you are traveling between the above points, take advantage of a water trip and save money.

Spend your vacation on the Great Lakes. Send for illustrated pamphlet. Address A. A. SCHANTZ, G. P. A., Detroit, Mich. ⁂

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Summer Homes.

In the Lake regions of Wisconsin, Northern Michigan, Minnesota, Iowa and Dakota, there are hundreds of charming localities preeminently fitted for summer homes. Nearly all are located on or near lakes which have not been fished out. These resorts are easily reached by railway, and range in variety from the "full dress for dinner" to the flannel-shirt costume for every meal. Among the list of names familiar to many of our readers as the perfection of Northern summer resorts. Nearly all of the Wisconsin points of tnterest are within a short distance from Chicago or Milwaukee, and none of them are so far away from the "busy marts of civilization" that they cannot be reached in a few hours of travel, by frequent trains, over the finest road in the Northwest—the Chicago, Milwaukee & St. Paul Railway. A description of the principal resorts, with list of summer hotels and boarding houses, and rates for board, will be sent free on application to GEO. H. HEAFFORD, General Passenger Agent, Chicago. ⁂

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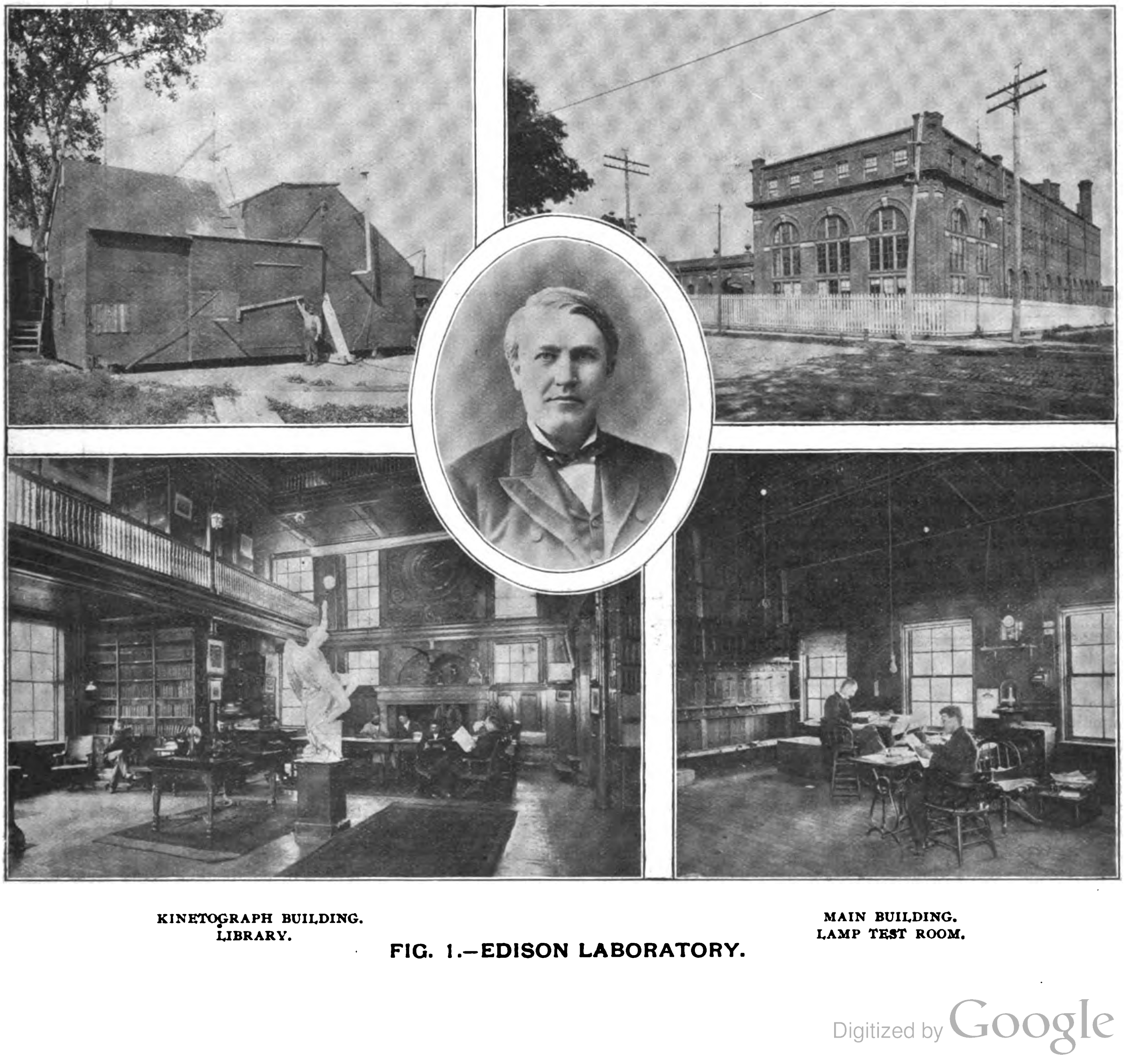
THE EDISON LABORATORY.

DURING the World's Fair those in New York who came in contact with foreign visitors recently landed, grew accustomed to hear, as their first inquiry, How may I visit Edison's Laboratory? As Fernay was to the intellectual world during the days of Voltaire, so in recent years has been the Edison Laboratory at Orange, N. J., to all, regardless of nationality, who have been dazzled by the achievements of electricity—achievements popularly never dissociated from the name of Edison. While this great interest most likely centers more particularly in the person of the presiding genius, the laboratory in itself well deserves the fame enjoyed, for, undoubtedly, nowhere in the world can its facilities be equaled for practical scientific investigation and inventive research.

Shortly after removing to his beautiful residence in Llewellyn Park in the Orange Mountains, Edison, some nine years ago, determined to realize his desire for a workshop and an equipment which would free him of the handicap he had formerly experienced in carrying on investigations. To this end no expense was spared, and the result is a group of buildings, erected on land adjoining the grounds of his residence, and an exhaustive stock of materials, which together are indeed worthy of him whom the French welcomed to Paris in 1889 with royal honors as the "King of the Industrial World."

The laboratory consists of a group of five substantial brick buildings and several frame additions. The main building is three stories high and about 50 ft. × 250 ft. in its ground dimensions. Flanking it on the left are four single-story brick buildings, each 100 ft. × 25 ft., and in the rear is a frame annex containing a photographic gallery. By the main gate is a lodge where visitors present their credentials and await the result of their endeavors to obtain a glimpse of the great inventor, which, it may be added, is not always possible. Though of an unusually hospitable disposition, and sacrificing a goodly portion of time in the reception of visitors, the exigencies of his work render it impossible for him to accede to all of the demands on his attention.

The front of the main building on the ground floor is occupied by the library, a handsome oak finished room two stories in height, and almost 100 ft. square. This is the only room in whose finish other than the most prosaic utilitarian considerations have been permitted to have play. On the wall at one end is a handsomely carved oaken



KINETOGRAPH BUILDING.
LIBRARY.

MAIN BUILDING.
LAMP TEST ROOM.

FIG. 1.—EDISON LABORATORY.

clock dial several feet in diameter, beneath which is a carved mantel and a huge open fireplace. A graceful marble statue in the center of the room adds a pleasing touch of lightness, very appropriately representing the Genius of Light—a winged figure poised on the broken shaft of a gas lamp and holding aloft a large incandescent lamp.

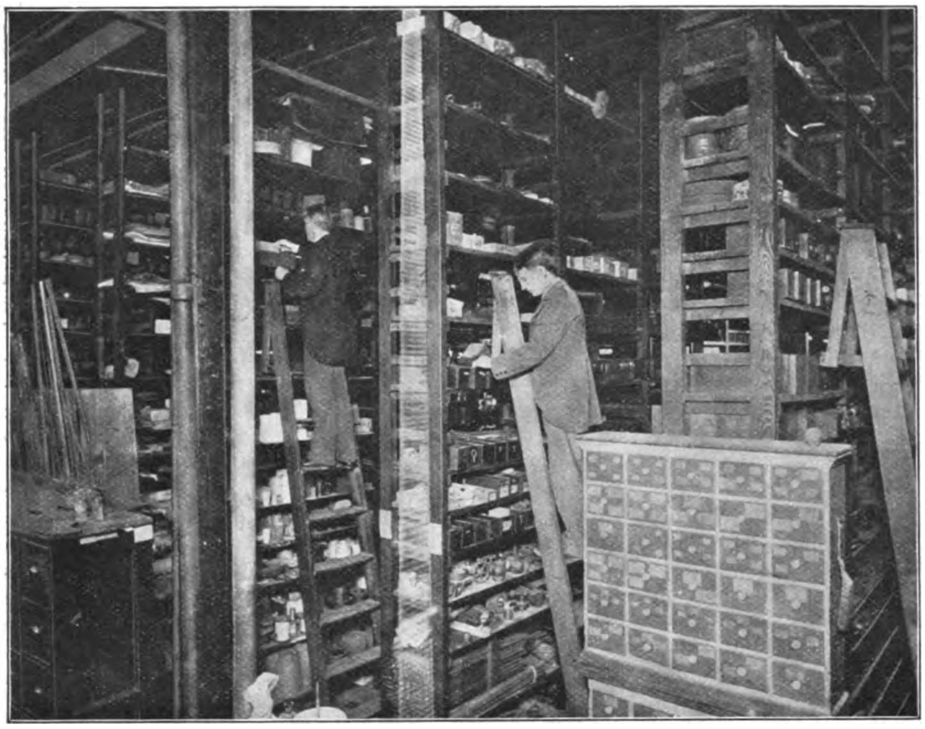


FIG. 2.—STORE ROOM.

From two sides of the room extend bays forming alcoves, the sides of which contain book shelves. More than 30,000 volumes are collected here, forming one of the most complete scientific libraries in the United States. A gallery above the alcoves extends around three sides of the room, and contains, in projecting bays, the great Tiffany collection of minerals, which was exhibited at the Paris Exhibition of 1889, and there purchased by Edison, doubtless to complete the marvelous stock of organic and inorganic substances, gathered from all parts of the world, which forms part of the equipment of the laboratory.

The rear of the building is occupied by the electrical generating plant, and the greater part of the remaining space on the ground floor by the storeroom, which contains what is perhaps the most wonderful collection of substances that has ever been brought together in the world, and incidentally gives an insight of the methods which Edison pursues in the course of invention.

Here on shelves and in drawers may be found almost every substance known to the organic and inorganic kingdom. As an example of the heterogeneity of the collection, in one section of drawers are a score or more complete fur skins, including seal, martin, grey fox, sable, etc., cat skins, dog skins, etc.; in another section are drawers containing albatross bones, rhinoceros horn, sea horse teeth, sharks' teeth, rhinoceros skin, fish bladders and innumerable other animal substances. Among the vegetable substances are even aloes, tonka and other beans, whose connection with invention it is difficult to surmise.

Wire is naturally well represented, not only in all materials, but in all sizes down to $\frac{1}{1000}$ in. in diameter, or the thickness of a hair. Of glass in the form of tubes, all the different varieties, such as German, Bohemian, etc., are here found. Insulating material of every variety is naturally included in stock, and there are innumerable kinds of hardware to supply a sudden demand arising in the course of an experiment.

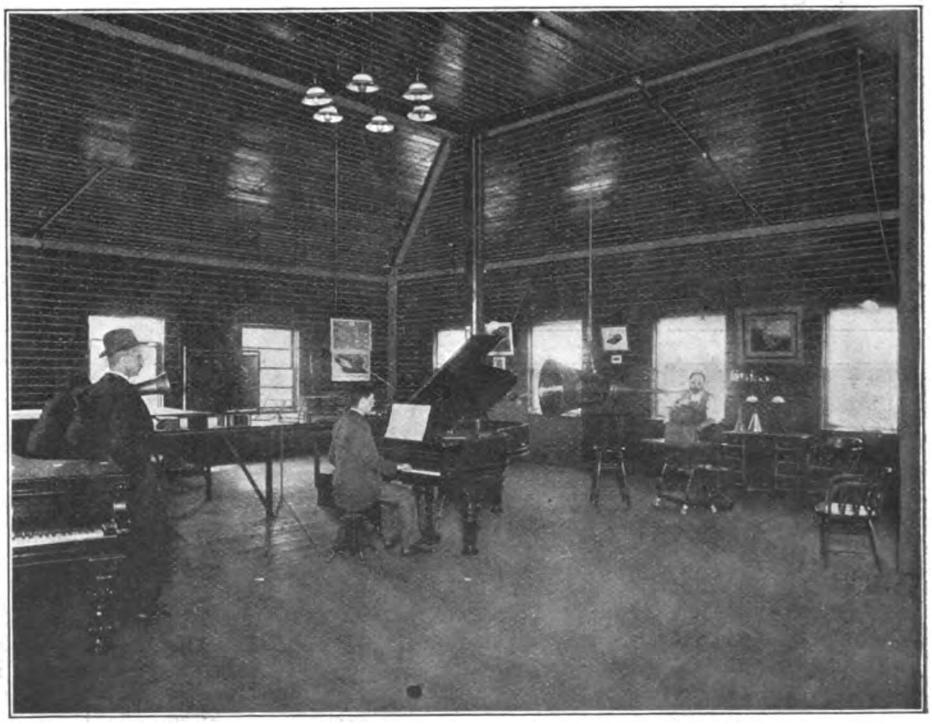


FIG. 3.—PHONOGRAPH ROOM.

It is in chemicals, however, that the richness of the stores is most apparent. There are literally thousands of bottles and packages in the storeroom, in one of the adjoining buildings (the chemical laboratory), and lining the sides of various rooms in the main building. In the former two places the chemicals are classified according to their nature; in one department nothing but extracts are seen, in another all of the acids are arranged together, while again the various compounds of an element will be found collected in groups, as for example, all of the bromines, iodines, etc.

These vast collections give a clue to the method of invention, if such it may be called, pursued by Edison, though with an inventor of his remarkable originality any method must play a very subsidiary part. Another illustration, and one more definite, was furnished at the time of the invention of the incandescent lamp, when an exhaustive collection of vegetable fibres was made in order to determine by a process of elimination, the best material for a filament. Many thousand specimens were obtained and tested, special expeditions being sent to several out-of-the-way parts of the world for this purpose. No less than 1200 varieties of bamboo were examined, and filaments from 300 of these made and tested. More recently the same system was pursued in investigations with the Röntgen rays. Vacuum tubes of the different kinds of glasses and of different thicknesses, were systematically tested, the services of a photographer were procured to make every known kind of sensitive plate and, later, every chemical possessing fluorescent properties, some scores in number, was in turn thoroughly tested in order that no shadow of a doubt should exist that the one thus fixed upon—tungstate of calcium—was the best. When one considers the striking originality of Edison's greatest inventions, in which such a process of elimination would seem to have had no part, surprise at the magnitude of the collections increases.

The upper two floors are divided into a

large number of rooms, each devoted to a specific purpose. Of these, the one of greatest current interest is that in which Röntgen ray experiments are being conducted. A view of the apparatus in this room is given in Fig. 5, which also includes a picture in laboratory attire of Mr. Edison, who kindly consented to thus pose before the camera for the benefit of the readers of the AMERICAN ELECTRICIAN.

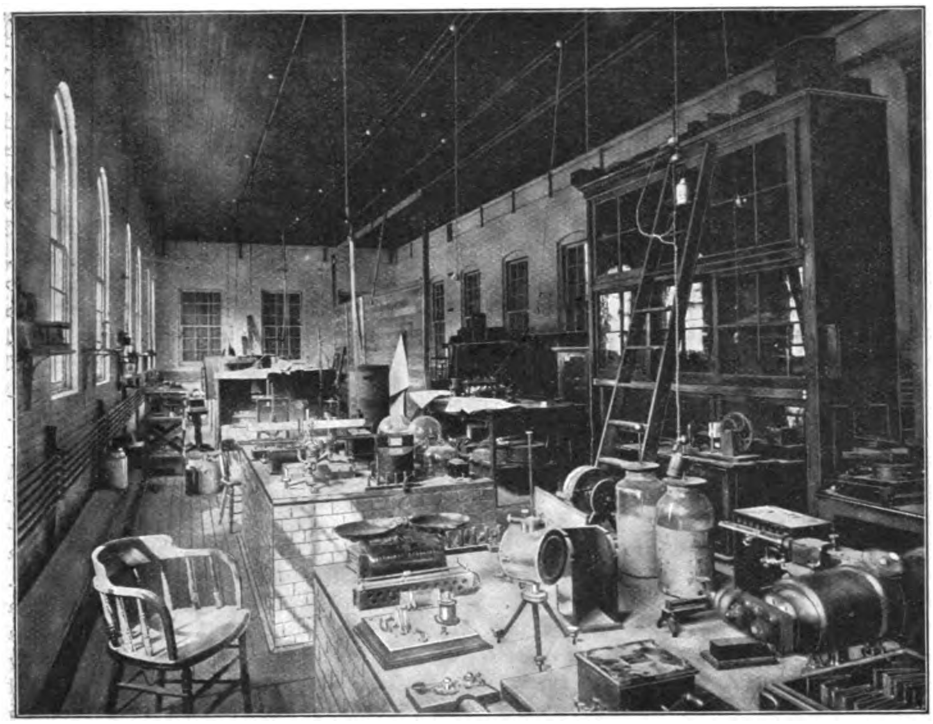


FIG. 4.—GALVANOMETER ROOM.

The apparatus here used for the production of Röntgen rays is very simple, consisting of a large induction coil, an interrupter wheel run by the motor, whereby a continuous current is changed into an interrupted current, and the primary of the coil fed with the latter. Overhead may be seen the Edison fluorescent lamp, which was first shown to the public on the day before it was photographed for our columns. It consists of an ordinary vacuum tube such as used in the generation of Röntgen rays, but with the interior walls covered with a fluorescent mineral fused into the glass. The light given forth resembles day light in its character, and though the small bulb shown only emitted an illumination equivalent to one or two candle power, yet this is the greatest intensity ever obtained in vacuum tube lighting. By the methods of measurement used, only six-tenths of a watt was required to illuminate the tube, or at the rate of about ten watts per sixteen candle power—only twenty per cent. of the amount required by an efficient incandescent lamp to produce the same illumination. The results obtained were startling to even so sanguine an inventor as Mr. Edison, who confessed doubts as to the applicability of the instruments used for such measurements.

Near the Röntgen room are two private experimental rooms from which all visitors are excluded. In these the teeming ideas of the great inventor's mind receive their first practical tests, and if some of the conceptions of which verification is here first sought were known, the world would doubtless be astounded by their audacity, even with the knowledge it has of the heights to which Edison has aspired and, moreover, attained. A peep which the writer was permitted to take into one of these rooms showed it to be a chemical laboratory, which recalls the fact that from the earliest days Edison has had a passion for chemistry. It was owing to a mishap with chemicals that as a youth his editorial aspirations were nipped in the bud. When fifteen years of age he published a daily newspaper on a train, but one day the car in which the paper was printed and composed was set on fire by chemicals with which he was experimenting, this accident bringing his journalistic career to an abrupt close. Several years later, when a telegraph operator, a similar mishap resulted in the loss of a position at Louisville.

On the same floor is a dormitory, which is a necessary apartment where experiments are at times prolonged for days without a moment's interruption. During the celebrated Röntgen ray experiments several months ago, work continued as long as fifty hours at a stretch, worn-out assistants at times catching a nap of a few hours during lulls. When thus engaged in a continuous investigation, Edison rarely takes any rest himself, or if he does, it may be only for a few moments at a time, between the beginning and end of an experiment. Like Napoleon, he possesses the rare power of being able to go to sleep immediately upon lying down.

That Edison has not lost his interest in the incandescent lamp is seen upon entering one of the rooms, shown in Fig. 1, where large numbers of lamps are kept burning under efficiency tests. Mr. Edison recently expressed the hope that he may be able finally to produce filaments taking fifty per cent or less current than present commercial lamps of the same voltage.

On the same, the upper, floor is the phonograph room in charge of Mr. Charles Wurth, where the still greater perfection of what is, perhaps, the most wonderful of Edison's many great inventions, is continually sought. Recently improvements have been made whereby the metallic timbre, formerly so noticeable in the audition, has been entirely obviated, or, at any rate, was not noticeable to the writer in several widely different renditions from one of the improved type.

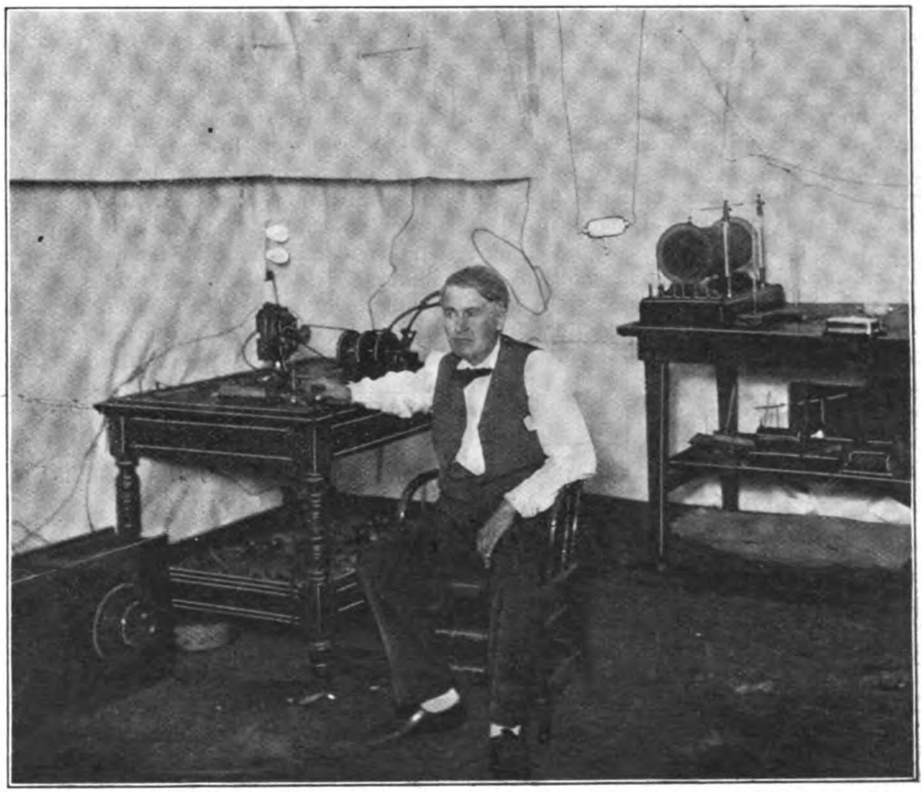


FIG. 5.—EDISON IN RÖNTGEN RAY ROOM.

Among other rooms in the main building, aside from a number of offices, are a furnace room for melting refractory substances and for other operations requiring a high degree of heat; a "precision" room installed with machine and other tools capable of doing work of the most superlative accuracy, and a machine shop containing tools with which a large steam engine or electrical generator could be completely fashioned.

Of the smaller buildings one, as stated before, is a chemical laboratory, and another contains chemicals and oils, thus isolated on account of their hazardous nature. A third contains a large ore separator from which the present machines at Ogden, N. J., were modeled. The separation of iron ore by magnetic means from the accompanying dross in the crude ore as mined, has long been a "hobby" of Mr. Edison, if such a word can be used in connection with an object which has been so earnestly and intelligently pursued. It is said that $2,000,000 have already been expended by the inventor in his experiments in this direction, and his ardor is unabated. The fourth building, called the galvanometer building, is filled with electrical instruments of various kinds, many of which are mounted on brick piers.

The most singular building of all is a peculiarly shaped wooden structure which, upon examination, is seen to be pivoted at the center, with wheels under the overhanging portion and having a bearing on a circular track. The "Black Maria," as it is known, is in fact a theatre within which are taken the pictures that, in the kinetoscope, so startlingly reproduce the motion of life. The building, by swinging it on its pivot, can be brought into the best position with respect to the rays of the sun. Within is a miniature stage, on which many and singular parts have been acted and reproduced true to nature by the kinetograph. The latter is a photographic apparatus for taking the instantaneous negatives, from which positives for the kinetoscope are subsequently prepared. If to this commonplace statement it is added that the series of photographs are taken at the rate of 165,600 per hour, some idea may be formed of the ingenuity of the apparatus.

Sandow, Carmencita, Buffalo Bill and his Indian chiefs, and the "Gaiety girls" are some of the celebrities who have here faced the lightning camera. On one occasion twenty-four actors performed a scene on the stage, and on another Corbett and Courtney had a bout with a loss of temper, it is said. This latter exhibition also furnished occasion for Jersey justice to show its inflexibility by haling those in charge of the "Black Maria" before court.

As to Edison himself, whose personality dominates so completely that ordinarily few visitors retain any but faint recollections of the laboratory itself, the following description, written some years ago by one closely associated with the great inventor, is a remarkably accurate portrayal of the man:

"The chances are ten to one that we will catch him in close communion with one of his assistants, giving instructions or receiving reports of experiments made. He is dressed in a linen duster that wraps his sturdy, well-knit figure from head to toe. But for this protection he would wear out or spoil a suit of clothes every week; in it, he will take up any piece of work that interests him, careless of consequences to his garments. As like as not, it bears the marks of recent grime and stain, the counterparts of which may be seen on the hand that is held out to us as its owner, with a generous sacrifice of the time he counts so precious, starts out on a hasty 'personally conducted' inspection.

"As he walks by our side we get an idea of what manner of man Edison is. He has outgrown the gaunt leanness of his youth and early manhood, and his face, once quite thin, is now rounded in outline. Over his massive forehead falls a shock of abundant brown hair turning here and there to bright silver. The nose is well cut. The face is smooth shaven, showing the strong lines of a mouth which has a smile lurking around it nearly all the time, yet whose lips take on them at intervals a chilling sternness of compression. It is in fact a mobile face, and the changes of expression gain their variety, too, from the flash and glance of his wonderful grey eyes. There is always, however, an intentness in his manner to which his deafness adds; though so quick of comprehension is he that we only learn of the defect by an occasional automatic raising of his hand to his ear. As he listens to a good story, of which, like Lincoln, he is heartily fond, his lips open, and the smile that besets them spreads over his in broader and broader ripples of enjoyment.

"Then he begins to tell us of some new idea he has, and with animated gesture he will literally carve the whole mechanism out of the air in front of us. Or perchance he speaks of some plan or work of which he does not approve. Each word cuts to the quick like a keen edge, and we shrink back involuntarily at the lightning flashes of his indignation. In our progress we come across the early beginnings of a new invention, and as we look at it and hear him speak of the countless failures that preceded this first success, we begin to understand how man in creating must be not less patient and persistent than nature itself. We also begin to understand the strange relations in which an inventor is placed to the world around him, not seeing a thing that he does not wish to improve and perfect, not making a step forward without realizing how much vaster is the area that opens up for the exercise of his talent. He must be not only a prince of dreamers, but a king of workers."

COMPRESSED AIR MOTORS.

Some excitement has recently been created in electric street railway circles by the claims of interested parties that, through great improvements recently made in the compressed air motor, it will become a rival to the electric motor in street railway traction. It appears that the Metropolitan Traction Company, of New York, is having ten cars equipped with air motors for a test. No information, however, can be obtained in regard to the "great improvements," either from the Metropolitan Traction Company, which is said to control the motor, or from those connected with the manufacturing company. It may be added that the compressed air motor has been used for some years at Nantes, France (Mekarski system), for street railway purposes, but not adopted elsewhere in that country.

HOW TO GET DIFFERENT KINDS OF CURRENTS IN A CHEAP AND SIMPLE WAY FOR EXPERIMENTAL WORK.

BY LIEUT. F. JARVIS PATTEN.

It often happens that the practical man, who, perhaps, runs an electric light plant or through other means has access to a station or a source of direct current, would experiment for himself if he could easily get the various kinds of current he would require for different experiments.

Probably few of these practical men in the electrical field have sufficient theoretical knowledge to do this for themselves unaided, and it is for the many who do not possess such knowledge that this article has been prepared and written in a way, it is hoped, that will make this matter clear to them and strip the subject of any apparent mystery.

What is generally first asked for is polyphased alternating currents of some description or other, say, two-phased or three-phased currents, or even a "single phase" alternating current may be desired—all at the command of the would-be experimenter being a direct or continuous current of fixed voltage.

Now it is fortunate in such cases that a direct current is at hand, for inasmuch as a direct current, is in fact, made up of many alternating currents rectified and superposed or bunched together, one can, by tearing the direct current to pieces, as it were, get almost any kind of alternating current we want, and generally as many of them as circumstances are likely to require.

In order to clear the electrical atmosphere, as it were, we should define what we mean by many-phased alternating currents.

First, a single alternating current is one that has a continuously fluctuating or changing value, and is generally represented by a sinuous line like *a*, *a*, Fig. 2, indicating a current that has alternating positive and negative values with intervening zero periods.

Now, if we had two such currents in which the negative values of the one, as *a*, *a*, always corresponded in time to the zero values of the other, as *b*, *b*, then such currents are known as being "in quadrature," and are called "two-phased" or "biphase" currents; and if there are three such alternating currents, equally spaced with reference to time, or having their maximum values occurring in rotation, as in Fig. 1, *a*, *b*, *c*, then such currents are called "three-phased" or "triphase" currents, and in general terms, when an alternator delivers two or more alternating currents, they are styled "polyphased" currents.

With such different alternating currents—single, two-phased and three-phased—a great many very interesting and instructive experiments can be made.

All that is required in order to get any of them is a direct current motor of suitable size and output, and which will admit of the simple and comparatively inexpensive changes indicated in the figures; and what is known to laboratory workers as a universal or double wound Gramme ring transformer, which the experimenter can generally make for himself, and which, if he does, he will find a most satisfactory outlay of time or money, because of its varied and extreme usefulness in all lines of experimental electric work.

About the direct current motor itself there is only one special and necessary requirement to be observed. It must have a comparatively long commutator, as indicated in Fig. 3, so as to admit of putting three sliding ring contacts on the commutator and still have room enough left for the brushes. This is not difficult to find, for the writer has observed quite a number of dynamos and motors that are so built.

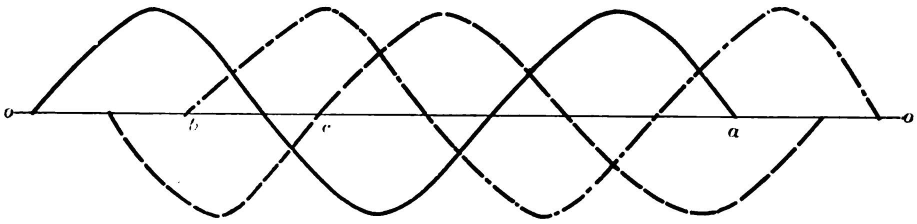


FIG. 1.

The alterations in the machine to be made will be understood from Fig. 3, in which *A* is the armature of the motor lying in the two-pole field *N* and *S*. Its commutator is indicated by the part *C*, and the ordinary brushes bearing on the commutator are indicated at B_1 and B_2 connected to the line of current supply L_1 and L_2.

Now the parts R_1, R_2 and R_3 of the same figure indicate three continuous brass rings as sliding contacts that are slid on over the commutator, being placed as near to each as possible without danger of causing the brushes bearing on them to interfere. They might not be more than ¾ in. wide on the face and, allowing ½ in. between, they would only take up 3¼ to 3½ ins. on the commutator, which is not excessive.

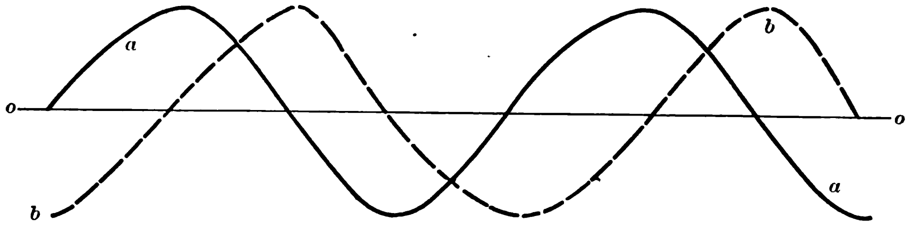


FIG. 2.

It should further be observed in selecting a motor for such a purpose, to choose one with a commutator having a number of segments, divisible by three, such as twenty-four, forty-eight, sixty or seventy-two segments.

When the rings are put in place, they must be all securely insulated from all the commutators except the particular segment which it is to be connected with and represents. To effect this, each ring, which is simply a continuous round brass ring of nearly square cross section, has an interior core of fibre or wood, which latter fits on tightly over the commutators and serves to hold the ring firmly in place. Practically, each ring represents one particular commutator segment continued all around the commutator, so that a brush bearing on a rim is in effect simply bearing on the same segment all the time as the commutator turns.

To effect this, the rings are drilled and a connecting plug or screw is driven in through the insulating part and into the particular segment to which it is desired to permanently connect the ring. Now it will be found simplest and best, as will appear later, to use these rings connected to three segments equidistantly spaced around the commutator, as indicated in Fig. 4, which shows ring R_1 connected to a segment at the top of the commutator ring, R_2 connected another a third of circumference around from it, and R_3 connected to another segment a third of the circumference further around in the same direction, or one-third back from the first, which is the same thing.

This arrangement will suffice for most anything desired as it is, but it will be found convenient in some cases to have one of the rings, as R_2, arranged with a second hole, as K_4, so that if desired it can be connected to a segment just half the way round or diametrically opposite to the segment to which R_1 is connected.

Equipped thus we are ready for work with single, two-phased and triphased alternating currents of high or low voltage, besides the direct current we originally start with.

Thus, to begin: The motor running on direct current supplied by the main leads L_1 L_2; then the leads connected to the brushes bearing on all three rings will yield three-phased currents like those shown in Fig. 1, to any three interconnected circuits. This last term may puzzle the practitioner and so it is, perhaps, best to explain what is meant by three interconnected circuits. To do this, consider Fig. 5, which is intended to represent a Gramme ring, which is given two independent windings, each alternate coil being in one winding, as the outer one, w_1 w_1, and the other connected separately as an independent winding, w_2 w_2. Now if we tap the outer winding, w_1 w_1, at three equidistant points, as L_3 L_4 L_5—that is to say, connect wires on to the winding at these points without breaking the winding open—then the outer winding will constitute three interconnected circuits; and if to these points L_3, L_4, L_5 are connected, the corresponding leads, L_3, L_4, L_5, from the motor rings (Fig. 3), then when the motor is running, two-phased currents will flow in these leads and through the interconnected circuits of the winding w_1 w_1, producing therein a rotary field—the first essential feature of a rotary field transformer or "universal ring" transformer, such as Fig. 5 represents, or of a Tesla rotary and commutatorless motor, which it likewise imperfectly represents.

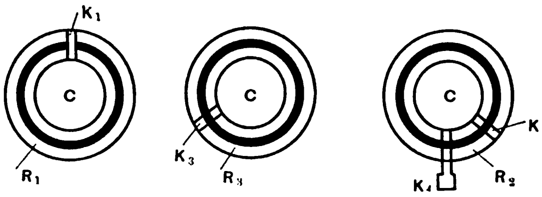


FIG. 4.

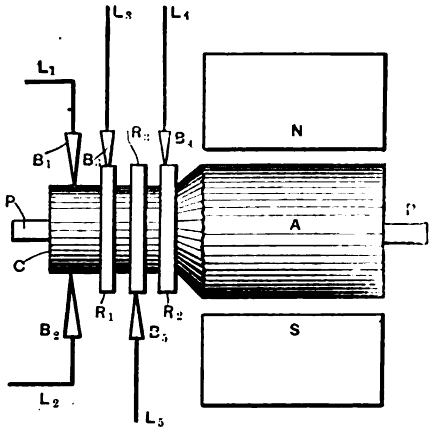


FIG. 3.

This rotary field is passing through the inner winding, W_2 W_2, also, setting up just such a field in it, and if we connect two leads to opposite points, 1 and 2, of this winding, then in these two leads we shall have a single alternating current like *A*, Fig. 2, as the result of putting triphase currents from the machine into the winding W_1 W_1.

So we get a single alternating current from our apparatus one way. If, on the other hand, we connect one pair of leads to the points 1 and 2 of the inner winding, W_2 W_2, and a second pair to the points 3 and 4 of this same winding, then in the two pairs of leads considered separately, or in interconnected circuits connected to all four of them, we shall have two-phased alternating currents or two alternating currents in quadrature, as indicated in Fig. 2.

It must be understood that the ring transformer, Fig. 5, does not move; it is a fixed transformer and may rest on a table where it is convenient to make different connections. It would appear that so much is enough to expect from such simple apparatus, and by altering the relative number of total turns in the two windings of the ring transformer, voltages may, of course, be changed up or down at will, at the same time the other transformations are going on.

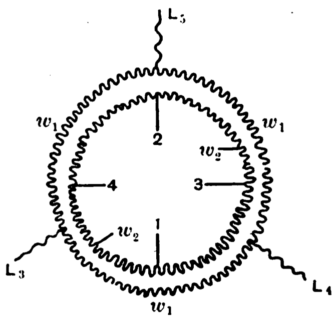


FIG. 5.

There is one other very interesting current to be derived from the motor transformer. Thus, let a lead, as L_3, be connected as shown to its ring, R_1, and a circuit made from it to another brush which shall simply bear upon the commutator proper itself. What then will flow in such a circuit? It is not difficult to figure this out, and it is left for the student.

THE VARIATION OF STEAM ENGINE ECONOMY WITH CHANGE OF LOAD.

BY PROF. W. F. DURAND.

It is a fact well known to users of steam power that a given engine does not, at all loads, work with the same economy. The case most commonly of interest to electrical engineers is that in which the speed of the engine remains sensibly constant, due to the action of the governor, while the cut-off and power vary continuously, corresponding to the changing value of the load applied. Thus an engine which is rated at 300 I. HP may, if on street railway service, be subjected to the widest fluctuations of load, and the power developed may, in the course of a few revolutions, vary from the frictional load of, say, 50 I. HP to as much as 400 I. HP or more. On lighting service, the power in the course of the night may likewise vary through a range perhaps as great as the rated power of the engine.

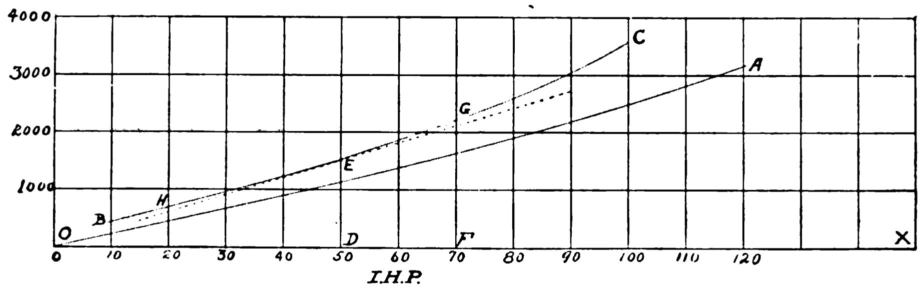


FIG. 1.

Now, in all such cases it is known that at or near some one load, the economy of the engine is the best, and that as the load is varied one way and the other, the engine becomes more expensive per unit of power developed. It results that in no case where the load on an engine is variable can we expect as good economy as when the load is uniform and the engine properly proportioned to such load.

In the present article, we propose to briefly indicate the causes of this variation in economy, with numerous examples, showing the nature and extent of the variation in engines of various types and working under varying conditions.

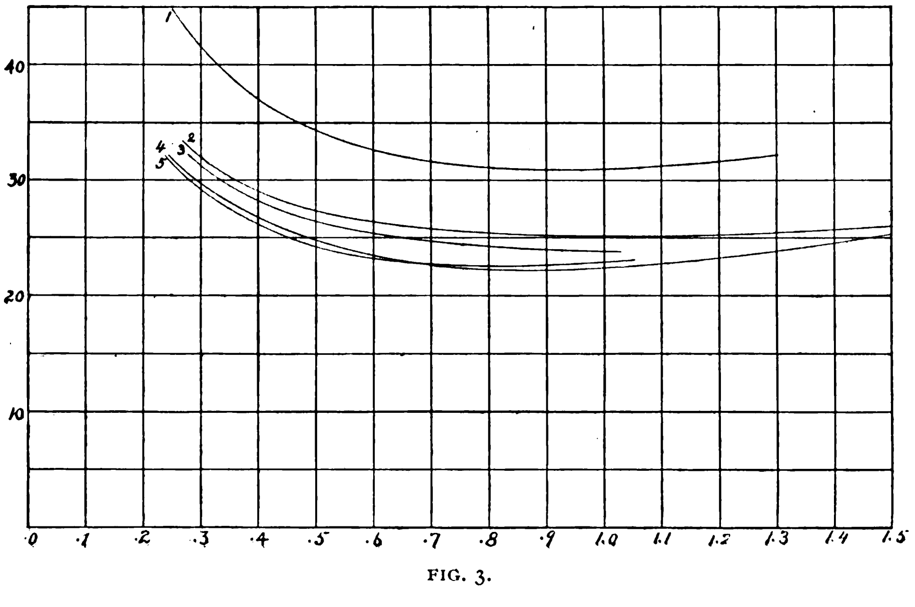


FIG. 3.

As already noted in this journal, the ideal efficiency of an engine may be expressed as a fraction, of which the numerator is the difference in the absolute temperature of the incoming steam and of the condenser, while the denominator is the absolute temperature of the former. This is the efficiency for a certain set of ideal conditions which are never attained in the actual engine. There are various other ways in which we may frame ideal conditions, under which we may conceive an engine to operate, all of them of more or less interest as furnishing a kind of standard of excellence to which we may refer the actual engine. We shall not here enter into the details of these various ideal conditions. It will be sufficient for our present purposes to note that under such conditions the economy in general increases continuously with the number of expansions, and hence, with a given engine and steam pressure, the earlier the cut-off and the less the amount of work done, the more economical would be the rate at which it is performed. For such case, therefore, the diagram of water consumption would be similar to Fig. 2, *A B*, where the power is laid off horizontally, and the vertical ordinates denote values of the corresponding consumption per I. HP per hour.

It is of interest to note the influence which such conditions would have, if attainable, on engineering practice. The economy being greater, the earlier the cut-off and the less the work performed by the given engine, it would result that for a given amount of work the economy would be greater, the earlier the cut-off and the larger the engine. The engines used would thus become larger and larger and the cut-offs earlier and earlier, until further extension in size would be checked by the increase in first cost and interest on investment, or by reaching a number of expansions sufficient to reduce the terminal pressure to equality with the back pressure.

This would be the result were the ideal conditions attainable. In the actual case they are not, and we, therefore, naturally ask why the real engine behaves so differently from the ideal.

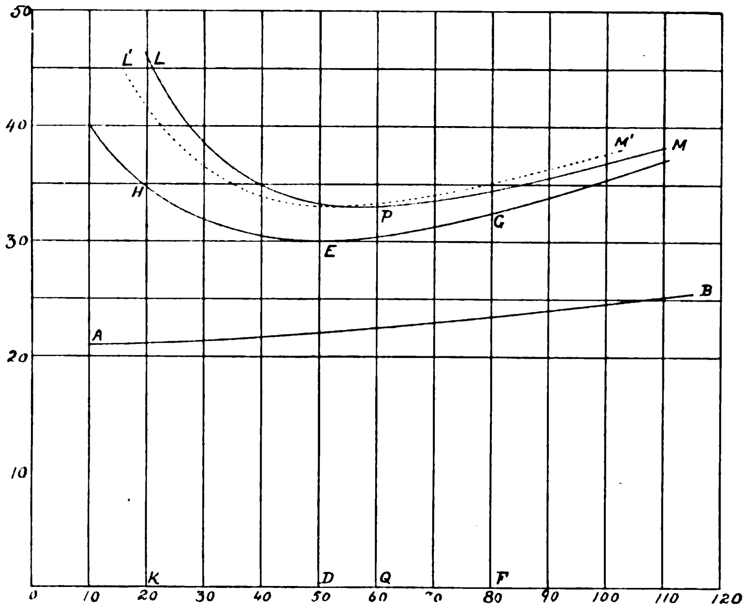


FIG. 2.

We must remember that fundamentally the steam engine is a heat engine, and that its purpose is to transform heat into work. Now, due to the fundamental laws which condition the action of all heat engines, only a portion of the heat supplied can under ideal conditions be so transformed; the fraction being represented by the ideal efficiency as above defined. The part which thus escapes transformation is, therefore, the minimum possible under the ideal conditions assumed. Actually, the amount of heat not transformed into work is considerably greater than the above minimum, and all such additional amounts are commonly termed heat wastes or losses. These various wastes may be classified as follows:

(*a*) *Radiation and Conduction Waste.*

This consists of heat which is radiated away from the hot surfaces of the cylinder or conducted away through the bed plate and foundation. The heat thus escaping avoids transformation into work, and is therefore to be counted as a heat waste, or as an expense from which no proportionate return is received.

(*b*) *Initial Condensation.*

At the instant the steam valve opens, the steam rushes in to find itself in contact with surfaces which have but recently been exposed to the influence of the condenser or the external air. They are, therefore, at a temperature lower than the steam, and in consequence a part of the heat is absorbed and a corresponding part of the steam is condensed. The heat thus absorbed by the surface of the cylinder will be given up later during the exhaust period of the revolution, and thus communicated to the condenser. It thus appears that a thin skin of metal on the inside of the cylinder may be considered as a kind of place of hiding, into which a portion of the heat slips on the entrance of the steam, and from which it escapes to the condenser or air without having taken part in the regular cycle of the engine, and hence without having contributed its part to the useful work done. Otherwise this action of the walls may be considered as a means whereby a part of the heat short circuits past the work producing cycle, and thus escapes. The heat which thus avoids the regular cycle appears as an expense, with no corresponding useful result.

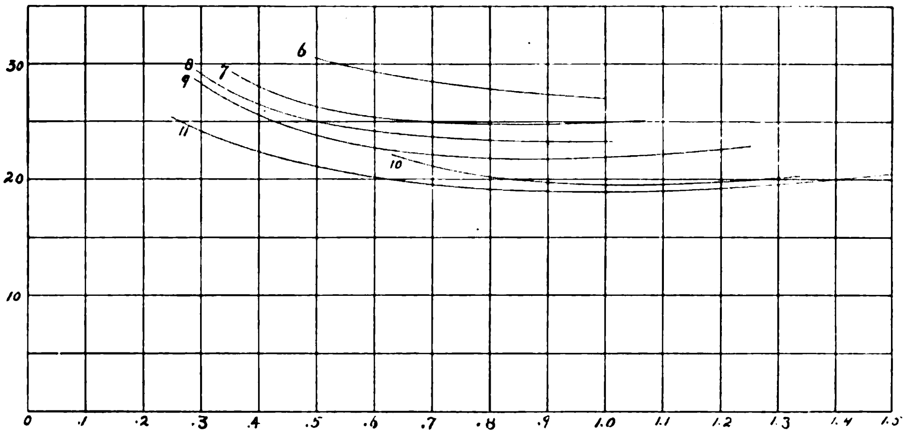


FIG. 4.

(*c*) *Irregularities in the Cycle.*

The nature of the operations which go on in the cylinder of a steam engine during a revolution are known to vary widely from those necessary for the attainment of the ideal efficiency. We cannot here enter into the details of this point, and the broad statement must suffice, that such departures from the ideal cycle do influence prejudicially the efficiency of transformation.

Now, without entering into the question of the individual variation of these losses, let us note their relation as a whole to the varying development of power in the same engine, revolutions and steam pressure being constant. To this end let us refer to Fig. 1. The total I. HP is laid off along OX, and the corresponding total water consumption per hour, vertically, as shown. For ideal conditions the curve would be something like OA. The waste would then necessitate an additional supply of steam represented at the various values of the I. HP by the intercept between OA and BC. The total water consumption in the actual case will therefore be given by the ordinate to the curve BC. The amount per I. HP per hour from any point will then be given by the quotient of the ordinate by the abscissa, or, for example, at the power OF, by $FG \div OF$. Now it is easily seen that at a point, E, such that the line, OE, is tangent to the curve at E, this ratio will have a smaller value than at any other point such as G or H. It follows that under the conditions assumed for the curve BC, the expense in pounds of water per I. HP per hour will be least at the power, OD, and will be greater as the power is increased or decreased from that value.

If now we plot values showing the consumption per I. HP per hour, we have curves as shown in Fig. 2, where AB is the curve for the ideal case, and HG that for the actual. The change from one to the other in amount and character is due simply to the influence of the heat wastes, as may be seen by a comparative study of the two diagrams. Referring to HG, we may note the characteristics mentioned in the opening of the article, viz., the existence of a load (here about 50 I. HP) at which the water rate is minimum and the economy maximum, and also the increase in water rate and decrease in economy as the load varies on either side of this value. Vertical lines measure water used.

It will naturally be expected that these various curves will vary with the steam pressure used, with the size and type of the engine, with the nature of the cycle followed by the steam, and, in fact, with all circumstances relating to the conditions affecting the steam from its entrance into the engine to its final rejection. We are more especially concerned with the curves similar to HG, and for graphical representation of their characteristics for various cases, we may refer to Figs. 3, 4, 5. These are plotted as follows:

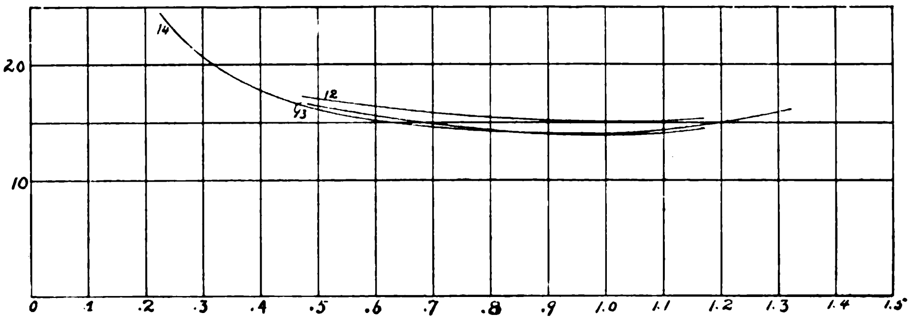


FIG. 5.

The data of a large number of tests have been examined, and in each case the power for best economy has been called unity. The various values of the I. HP developed on the test have then been expressed in terms of this unit, and the corresponding values of the water consumption per I. HP per hour laid off. The series of curves thus found have their minimum ordinate at abscissa 1, representing the point of maximum economy. In order to connect these ratio values with the actual I. HP developed, the value of the I. HP for abscissa 1 is given in each case, as well as the type of engine and steam pressure. Thus, for example, in Fig. 4 on curve No. 11, at abscissa .6 we have an ordinate 20.2. For this curve 1 represents 81 I. HP. Hence the actual power at this point is 48.6, and at this power the given engine required 20.2 lbs. of water per I. HP per hour.

A careful study of these curves will be found of great interest and value. We can here only note a few general conclusions which may be drawn from them.

(1) The economy in general is better as the steam pressure is higher.

(2) The economy in general is better for condensing than for non-condensing engines, for compound than for simple, and for triple than for compound.

(3) The curves rise somewhat more sharply for decrease of power below the value for best efficiency than for increase beyond such point.

(4) The curves for triple and compound engines are in general flatter than those for simple engines, or, more generally, the lower the best water rate, the flatter the curve and the less rapid the increase for variation on either side of this value.

(5) As a consequence of the (3) it follows that so far as economy is concerned, we may usually obtain better results from over-loading than from under-loading an engine by the same relative amounts. As a matter of common practice, engines are more commonly under-than over-loaded, and hence the varying load is not taken in the way best for economy. This is due to two chief causes. (*a*) Engines are often put in somewhat larger than immediate calls would require, with the expectation that the demand will increase shortly into keeping with the rated power of the engine. This may be true but it results in the meantime that the engine is being used on the more uneconomical side of its best point. (*b*) The engine itself may be designed, so far as its strength and provision of wearing surfaces are concerned, more especially with reference to its most economical load. In such case it might not be considered safe to allow the fluctuations to rise to an excessive overload, even should such method of operation be favorable to economy.

There seems reason to believe that, in general, for best results with varying loads, plants are usually somewhat overpowered, and that smaller engines run at a range of fluctuation, which at the maximum would carry them well beyond their most economical load, or their normal rating, would be favorable to somewhat better economy. The difference may be appreciated by considering again Fig. 4, curve 11. In one case if we suppose the power to vary from .28 to 1.05, the water consumption will vary from 24.5 to 19. In the second case, with an engine of about .7, the same normal power, the same range of fluctuation would be from .40 to 1.50, and taking the some curve for values of the water rate, we should have variation from 22.5 to 19, with an average economy certainly better than in the first case. The smaller engine would also have somewhat smaller heat wastes, especially in item (1), as above noted, and this would be still further favorable to a decrease in the best water rate. The decrease in size of engines may, of course, be carried too far, and it is only where the fluctuations are wide that these considerations become of importance. But in such cases, it is obviously better to have the best economy occur somewhere near the middle of the range of fluctuation, rather than at one end of it.

It may now be asked as to the power at which any given engine is likely to give its best economy, or as to the power corresponding to the (1) of Figs. 3, 4, 5. This likewise will depend on the various circumstances, and we can only indicate in a general way that for simple engines and moderate pressures the power will be most economically developed at about three to five expansions, while with compound and triple expansion engines and steam pressures rising to 100 lbs. or 150 lbs., the number of expansions may be carried to from six to twelve. In general the builder's rating is very near the power for best economy, and in default of more definite information, this may be taken with confidence, as not far from the point desired.

We may next briefly examine the influences on the preceding considerations, of taking as the basis, the delivered, instead of the indicated, horse power. The earning capacity of an engine is more nearly represented by the former than by the latter, and hence it may be more properly made the basis of investigations relating to the economics of power production. It is well known that at constant speed the power absorbed by the friction of an engine is nearly constant, and for illustrative purposes we may take it at from ten to twelve per cent of the I. HP, for best economy. These values are fair averages of the results of many experiments on engine friction. It may then be seen that if in Fig. 1 we should divide each ordinate of BC by its abscissa minus ten per cent of OD, as representing the D. HP, the quotient would give the water per D. HP, per hour, and the result, if plotted in I. HP, would be a curve, LM, Fig. 2, while if the abscissa is taken as the D. HP, it would be represented by $L^1 M^1$. The curve LM is naturally higher than HG. Any point such as P indicates that at I. HP $= OQ$, and hence D. HP $= (OQ - .1\,OD)$ the water rate per unit D. HP is QP. Now an interesting feature of the curve is that the minimum point is at or near P, corresponding to an I. HP $= OQ$, instead of OD, as when the I. HP is taken as the basis of reference. That is, with I. HP $= OQ$, the power per D. HP costs less than for I. HP $= OD$, although the latter is the point for best economy when I. HP is taken as the basis. It follows that the best condition relative to D. HP is at a value of the I. HP, somewhat beyond that for the best result per unit I. HP. This is a still further reason for running an engine under varying load well beyond its rate for best results per unit I. HP.

The curves of Figs. 3, 4, 5, while intended as a presentation of only a part of the available data relative to variations of economy with load, will serve as a basis for a general estimate of the variation in any given case.

Table I.

DATA RELATING TO FIGS. 3, 4, 5.

No. of Curve.	Type of Engine.	Value of Unity.	Gauge Pressure.
1	Simple non-condensing....	76	77
2	" " "	26	75
3	Automatic non-condens'g.	170	100
4	Simple condensing..........	45	110
5	Same as 3	210	120
6	Compound non-condens'g	100	60
7	" " "	140	80
8	" " "	170	100
9	" " "	170	120
10	" condensing.....	89	110
11	" "	81	110
12	Triple "	100	125
13	" "	125	125
14	" "	112	120

The following table gives the best values likely to be attained with the various types of engines as given in the headings, and these together with the general trend of the curves in the various cases should give a fairly satisfactory basis for an estimate in any given case. Equations have been proposed intending to represent such curves, or to give in algebraic form the variation of economy for a given engine. Such might be here presented, but it is believed that for the purpose of the present article, it is better to let the curves stand as the embodiment of the data presented. In regard to these curves, it should be noted that they are simply smooth curves drawn through and between the spots determined by the actual experiments. The actual spots are omitted for the sake of simplicity in the diagrams, and the curves may therefore be considered as an approximation to the law indicated by the distribution of the spots determined, rather than as giving the exact experimental values themselves.

Table II.

PROBABLE MINIMUM WATER CONSUMPTION FOR VARIOUS CLASSES OF ENGINES.

Class of Engine.	Gauge Pressure.	Water Consumption.
Throttling non-condensing.................	80	35—45
Automatic non-condensing	80	30—35
" " "	100	20—30
Corliss simple non-condensing...........	80	25—30
Compound automatic non-condensing.	100	24—28
" " " "	125	21—25
Corliss simple condensing..................	80	22—26
Compound automatic condensing........	100	18—24
" " "	125	16—20
Corliss compound condensing............	100	16—20
" " "	125	15—19
Triple expansion condensing.............	125	14—16
" " "	150	13—15

The above values are more especially intended to be applicable to engines of moderate size, as for example, 100–500 I. H. P. The economy in general increases and decreases with the size of the engine.

THE USE OF GLOBES.

BY PROF. GEO. D. SHEPARDSON.

The globe about an electric or other lamp may be considered as both a mechanical and an optical device.

As a mechanical device the globe of an arc lamp acts as a wall of separation between the arc and the outside air. The globe prevents the wind from blowing the arc from side to side and thus making the light unsteady and less intense. It prevents inflammable substances from coming into contact with the arc and so causing fire. The globe prevents particles of hot carbon from flying out from the arc and dropping where they may be dangerous. In the case of arc lamps operated by alternating currents, the globe also helps deaden the humming sound that might be objectionable with a naked arc. With the enclosed or "incandescent" arc, the globe also serves to prevent access of air to the arc. This allows the use of a longer arc and reduces the shadow cast by the lower carbon. It reduces the ordinary combustion of the carbons, and thus reduces cost of carbons and trimming. It also reduces the cooling of the carbons by currents of air, and so increases the efficiency to some extent.

The globe of an incandescent lamp is necessary for the maintenance of the vacuum. The incandescent filament would be burned up almost instantly if air should come in contact with it. The vacuum is also desirable to prevent currents of air from cooling the filament and so reducing both the light and the efficiency. Currents of air would also soon wear away the filament by air washing. The globe also protects the fragile filament from mechanical injury.

So far as the above mechanical reasons are concerned, the globes might be made of metal or some other substance less fragile than glass. But the globe must also possess certain optical properties. It should be either transparent or translucent. A transparent substance allows light to pass through with as little obstruction as possible. With a perfectly transparent globe, the source of light would be clearly seen, while the globe itself would be invisible. On the other hand, with a perfectly translucent globe, the real source of light would be invisible and the globe itself would seem to be the source of light. As a matter of fact no globe is either perfectly transparent or perfectly translucent, but approaches one or the other limit more or less imperfectly. Which of these qualities is desired in a given case will depend both upon the purpose for which the light is to be used and upon the location of the lamp. This involves some discussion of the elementary principles of lighting.

Lights may be used for illumination, for illumination appearance, or for both purposes. The difference between illumination and illumination appearance is not as commonly or as well understood as it should be. Illumination appearance is obtained when the sources of light are conspicuous, as in the case of lighthouses, railway signal lights, luminous signs, etc. Illumination without illumination appearance is obtained when objects to be seen are well lighted, but when the lamps or other prime sources of light are not seen. A combination of the two is often desired and more often secured.

The character of the globe used with lamps, as well as the disposition of the lamps themselves, will vary according to the effect desired. Where intense illumination appearance is desired, the globes should be as transparent as possible, being omitted entirely if practicable, so that the source of light may be undimmed. Clear globes are, therefore, indicated for arc lamps for street lighting, especially if the lamps are two or more blocks apart, so as to show directions rather than to light up the roadway. Also where lamps are so located that neither the lights nor their reflected images may come within the range of vision of the persons using them, it is desirable, as a rule, to use clear globes or none.

In the vast majority of cases it is impracticable or undesirable to place the lights out of sight, so that it is an important question how to modify the light so as to give satisfactory illumination or illumination appearance or both.

Clear vision requires two conditions: First, that the objects to be seen shall be suitably illuminated, and, second, that a suitable eye be present to see them. The conditions that affect the eye are, therefore, of importance.

The eye has an automatic protective device, known as the iris or curtain, which, by opening or closing, regulates the amount of light that may enter and give the sensation of light. When the light is too intense, or when the changes of intensity are too great, the action of the iris is helped by closing the eyelids as in blinking. The iris automatically closes more or less so as to reduce to a safe limit the total amount of light entering the eye. It follows that the iris adjusts itself to limit the amount of light received from the most intense luminous source within the range of vision. Objects become visible only as light is radiated or reflected from them, so that they themselves become sources of light. The quantity of light that enters the eye from an object depends both upon the brightness with which the object is lighted and also upon the adjustment of the iris. If the lamp itself is seen by the eye, the iris contracts accordingly, and, as a further result, a correspondingly less amount of light comes from other objects.

It is therefore desirable that the prime sources of light shall be kept outside of the field of vision, or else be so reduced in intensity that the iris will still open far enough for the eye to receive a sufficient amount of light from other objects. The field of vision is described as a cone having the eye at its apex, and having a base whose outer edges make angles with the center line varying from 50 to 95 degs. As the eye changes position frequently to rest itself, the sources of light should be removed outside of a cone considerably wider than the angle of vision.

When it is necessary to have the prime source of light come within the angle of vision, its intensity should therefore be diminished. The total amount of light given by any source is the product of the area of the source by the intensity or quantity of light per unit area. It follows that a moderately intense light of considerable size may give out as much light as one more concentrated and more intense. The light with a larger surface has the further advantage that it does not cast so sharp shadows and that it gives more of a perspective to objects illuminated, so that they do not look so flat as when illuminated from a single concentrated light.

The intensity of a light may be diminished and its apparent area increased by the use of a translucent globe such as ground or white glass or porcelain. The globe stops part or all of the direct rays of light, and each point of the globe becomes a secondary source of light. Some of the light is degraded into heat in passing through the glass, and even clear glass may thus absorb as much as twenty per cent. of the light. Ground and opal globes absorb from twenty to sixty per cent. of the light. Ground glass is objectionable because it gets dirty and opaque so easily, and is so difficult to clean. The opal globes not only increase the apparent size of the source of light, but they also give a more uniform distribution of the the light on account of internal reflection.

While opal globes greatly reduce both the intensity and the quantity of light given out by the lamp, yet the quantity is reduced less than the intensity. The iris of the eye opens so much wider when the opal glass is used that one can see better than with the more intense light through a clear globe.

This conclusion is being more and more generally recognized, and lamps for interior illumination are either placed near the ceiling or otherwise out of direct field of view or else are provided with suitable shades and globes. Streets are also being lighted with better results than formerly. Arc lamps are being suspended from higher poles or from mast arms, so that the arc is at least thirty feet above the roadway, more largely out of the range of vision. The use of opal globes, which seems to be nearly universal in Europe, is coming to be more common here, as those in charge realize that the purpose of the lamps is to illumine the roadway and not to blind passers-by.

A further advantage coming from the use of globes is the reduced trouble from direct or angular reflection. By spreading the source of light over a larger area, the regularly reflected light from each portion becomes less intense, and the glare is correspondingly reduced.

The above suggestions indicate that the proper use of globes is a subject well worth careful study.

THE LATE FRANKLIN LEONARD POPE.

Francis W. Jones, electrical engineer of the Postal Telegraph Company, in a sympathetic and ably written "In Memoriam" article, contributed to the *Transactions* of the American Institute of Electrical Engineers, on the late Franklin L. Pope, whose untimely death, by electric shock, last October, is yet so keenly felt by the profession which he honored, narrates several interesting episodes in the life of Mr. Pope.

One of these refers to the time of the draft riot in New York, in 1863, when the telegraph wires were cut down by the rioters, interrupting all telegraphic communication with the city at a very critical period of the country's history. Mr. Pope was assigned by General Lefferts to the duty of restoring communication between New York and Boston. The lines were found destroyed in many places along the railroad between Williamsbridge and Forty-second Street in New York, and also in the southern portion of Westchester County, all that territory being under the surveillance of the rioters. Mr. Pope disguised himself as a farm laborer, and with a portable telegraph instrument and repairing tools concealed in a sack of oats, started from New Rochelle, and protected by a dark, foggy day, walked over the fifteen miles between that place and Harlem River, and during the succeeding night connected up one of the fragmentary wires and restored telegraphic communication to Boston, notwithstanding that he had to run the gauntlet of the enemy's pickets. At one time during the night he was captured, but so well did he play his role of a rustic, that he was liberated unharmed; at another time, a little later, he was attacked at a point near Morrisania by a gang of at least fifty rioters, armed with knives and pistols, but he eluded his assailants in the darkness by concealing himself in a cornfield until he was able to proceed unnoticed and complete his dangerous task. The single wire so connected ran along fences, under station platforms, and was carried mainly by trees and bushes close to the ground, so that it was not distinguishable from the wrecked wires cut from their regular supports on poles. Thus was restored an unsuspected avenue of telegraphic communication that was of great public importance.

Another incident related occurred in Alaska, in 1865-6, when Mr. Pope was a member of the exploring and surveying expedition sent out to fix a route for a proposed telegraph line to Europe by way of Behring Strait. A great part of the territory had never been visited by white men, and trouble was apprehended from some of the Indian tribes. In one case, Mr. Pope called a grand council of Indians at Fraser Lake, and explained to them the object of his trip through their country. In order to convey to their minds some idea of the nature of the telegraph, he strung a wire upon small poles, a distance of several hundred yards, and made a circuit with a portable intermediate battery and pocket instruments. At one end of the wire, Mr. Pope arranged a pistol in such a manner that it was fired by the Indian chief closing the distant key. This performance was voted "great medicine," and was repeated many times, to the wonder and delight of the savages. The chief stationed some of his braves at the farther terminal of the circuit, to which end Mr. Pope also repaired, and without their knowledge the chief had Mr. Pope's brother, Ralph (now secretary of the American Institute of Electrical engineers), transmit a message asking for a piece of tobacco, which was promptly conveyed by a courier and presented to the chief, causing great astonishment and an immense outburst of "Chinook" jargon. This admirable "medicine," together with very generous gifts, particularly tobacco, the acme of an Indian's desires, had a propitiatory effect, and elevated Mr. Pope to a high pinnacle in the savages' esteem.

ORNAMENTAL ARC LAMPS.

SIR HUMPHREY DAVY, to whom credit is popularly assigned for the first discovery of the arc light, would, if he were to return to the earth, doubtless view with mingled feelings the present state of arc lighting. From the utilitarian standpoint, it is needless to say, he would be amazed at the enormous commercial consequences which have proceeded from experiments that at the beginning of the century were mere laboratory curiosities. On the other hand, if possessed of æsthetic sensibilities, his satisfaction would not be unalloyed, as he could not be blind to the hideous appearance of the usual arc lamp.

In an interesting paper read before the recent meeting of the National Electric Light Association, Mr. L. H. Rodgers, made the statement that the arc lamp, as we commonly know it, "is mechanically and electrically the poorest designed and constructed piece of mechanism on earth," and also asks "Whoever heard of a beautiful arc lamp?" It would be beyond the scope of this article to discuss the first statement which, even if too sweeping, may nevertheless have the good effect of turning attention to the perfection of an apparatus that has undoubtedly been sadly neglected in the past. The accompanying illustrations, however, will, we believe, show that though perhaps rare, arc lamps possessing the attributes of beauty are not only not unknown, but that there are no insuperable difficulties in giving them a handsome exterior.

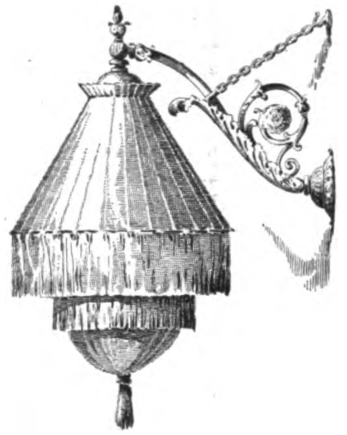


FIG. 1.

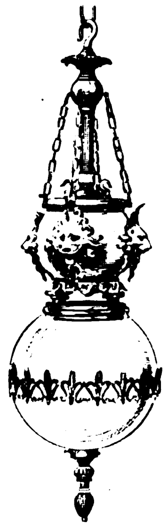


FIG. 2.

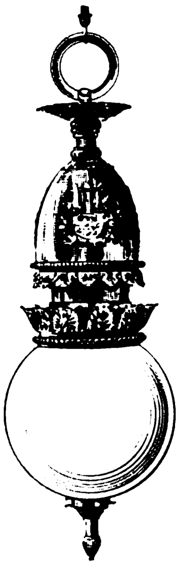


FIG. 3.

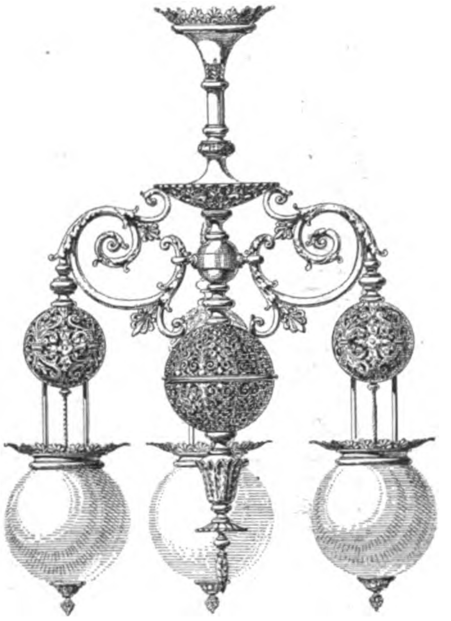


FIG. 4.

The problem of producing an arc lamp artistic in appearance is, nevertheless, not a simple one, if the rod arc lamp is the subject. Again quoting Mr. Rodgers, "We find a device fifty inches or sixty inches long, made of long tubes or chimneys * * * long side rods, and at the bottom a globe holder." In the earlier days of the arc lamp, manufacturers seem to have considered the conditions thus presented as offering a hopeless case, and took no advantage of the few elements of sightliness that were within reach. For example, notwithstanding that the spherical globe and cylindrical rod tubes naturally suggest a cylindrical shape for the case covering the mechanism, this latter was given the form of a rectangular box, which crude design is not yet entirely discarded.

The double carbon rod arc lamp will probably continue to defy the ability of the artistic designer, but the illustrations we give of ornamental rod single carbon lamps show that he has here had a number of solutions to offer. Indeed, the problem reduces itself to one of graceful proportions alone, for the case itself can be fashioned in almost infinite variety. With artistic proportions, the lamp will present a pleasing appearance with even a cheap finish, and bring out the full effect of expensive ones. Earlier ornamental arc lamps were defective from lack of recognition of this principle, expensive casings and elaborate ornamentation being alone relied upon.

Particularly pleasing examples of what may be accomplished in this respect are shown in Figs. 2, 11, 15 and 5, the latter a ceiling lamp.

By dispensing with the carbon rod, the conditions for ornamentation are immensely simplified. The chain lamp can be reduced in length by an amount more than equal to the length of the upper carbon, and as the difficulty found by the designer in the rod lamp lay almost entirely in its attenuated height, the amelioration thereby permitted is evident without reflection. The difference thus introduced is strikingly illustrated in Fig. 1, and in the ceiling lamp shown in Fig. 7. The slow introduction of the chain lamp can scarcely be ascribed to any difficulty in its operation, and is most probably due to the singular apathy, before referred to, with which the arc lamp has been regarded.

In Fig. 4 is shown an arc lamp chandelier (with one of the lamps removed), which form of hanging would seem to entirely obviate the objections to the use of the arc light in church and other interiors, where a number of units distributed would not be thought of. Heretofore, incandescent lamps have been used where electric lighting has been adopted for such places, but ornamental arc lamps grouped in a chandelier would not only give a more appropriate illumination, but, as here shown, admit of an excellent artistic effect in the fixture. Through the use of diffusing globes, ladies would not need to fear for their complexions, and incandescent lamps could still be used as auxiliaries for lighting passages and nooks.

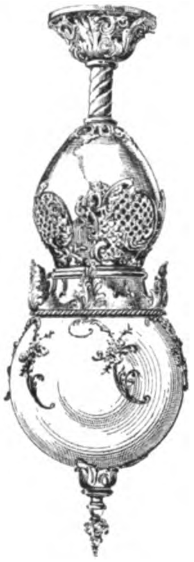


FIG. 5.

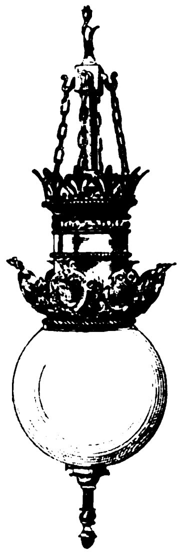


FIG. 6.

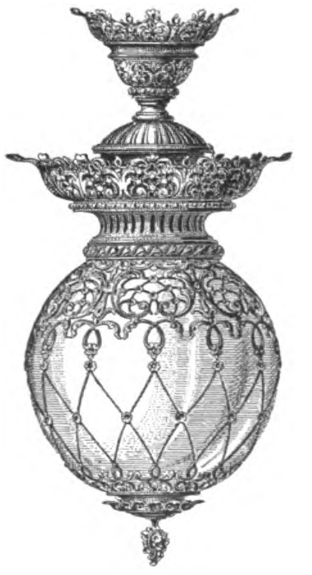


FIG. 7.

The matter of the suspension of arc lamps is one that thus far has received little attention. An arc lamp chandelier is a most decided novelty, while in most places where ornamental arc lamps are used, they are merely suspended as happens to be most convenient, with no eye to effect, and, perhaps, with the leading-in wires dangling about the case, or attached to slovenly open wiring. When brackets are used, they often are merely of rough iron obtained from the nearest blacksmith shop. The only object in paying an extra price for a handsome lamp is to secure a superior effect, but often the result, if there be a noticeable incongruity, is to create the reverse of the impression intended.

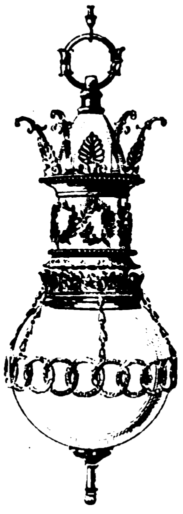


FIG. 8.

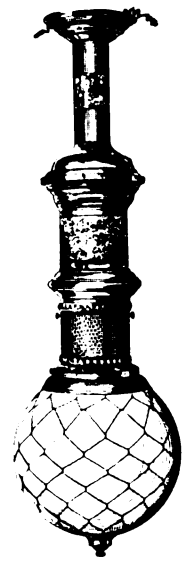


FIG. 9.

For the designs from which the above illustrations were made, we are indebted to the courtesy of the General Incandescent Arc Lamp Company for Figs. 1, 4, 7, 10, 12 and 15; to the Adams & Westlake Company for Fig. 9; to the Manhattan General Construction Company for Fig. 11; and to the General Electric Company for Figs. 2, 3, 5, 6, 8, 13 and 14.

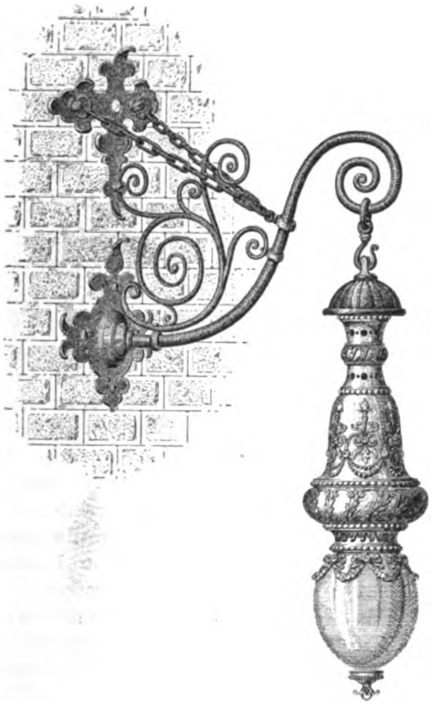


FIG. 10.

CENTRAL STATION ECONOMY.

In a paper read before the April meeting of the Chicago Electrical Association, Mr. Thos. C. Grier gave a compilation of points relating to little economies practised in central stations, obtained from letters written by central station managers in reply to a request for suggestions on that subject.

Two men from different parts of the country wrote that ashes or cinders can be sold, as they are good for roadways and filling; one of them states that his company receives twenty-five cents a load for ashes. The wetting of coal is for the purpose of laying the dust and it should not be carried to excess, as all the superfluous water has to be evaporated and thus uses up fuel without doing any good. One man wrote that $50 or $60 spent for a platform scales for the boiler room will, if the scales is intelligently used in weighing coal and cinders, soon pay for itself and teach one the most economical fuel for the purpose.

The secretary of a well equipped station describes the following arrangement for oiling dynamos: "We have an oil reservoir from which overhead pipes run to each machine. The pipes extend downward and have an opening directly over oil cups; this makes clean work and is very convenient. We have two good filters and all oil is filtered over and over again. We have had this simple rig in use about two years, and it reduces the expense for oil and waste one-half. In February the entire expense for oil and waste was $7.35 for the following machinery: two 60-K W and two 120-K W alternators five 50-light arcs, one 90 K W and one 150-K. W. generators, with all shafting, clutches, etc. The expense for oil is less than $100 per year."

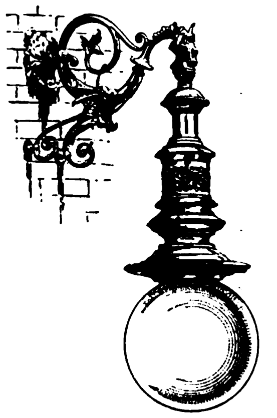


FIG. 11.

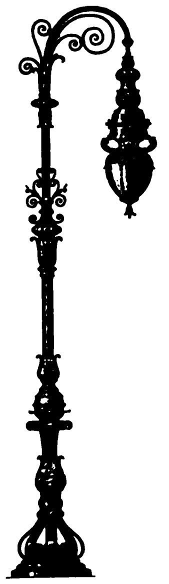


FIG. 12.

Another station manager finds much saving from the use of an oil filter. With seventeen arc dynamos, three alternating dynamos, each with separate exciter, and one fifty horse power generator, he uses three barrels of oil per year. Ten of the arc machines run all night and one incandescent dynamo day and night. A good oil, he says, will stand filtering a number of times.

A good method of cleaning dynamos is employed in a station in Wisconsin. A pump forces air into a small compressed air reservoir, from which small pipes run to the dynamos. There are valves near each machine. A small rubber hose with a nozzle is attached to any pipe, and in a minute the dirt in or on a machine can be blown away. This cleans parts that cannot be reached by the hand and saves repairs.

Two station managers give suggestions in regard to brushes. One states that on his arc machines two five-fingered and two six-fingered brushes are used on the commutator, which makes the wear even, no ridges being cut in the bars.

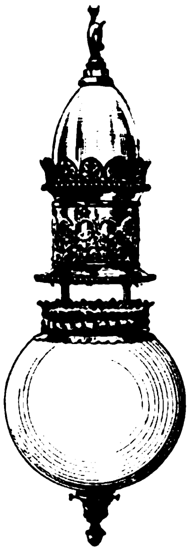


FIG. 13.

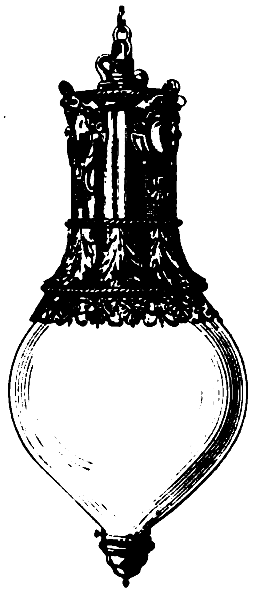


FIG. 14.

Certain types of dynamos have carbon brushes bearing straight or end on the commutator. The springs which feed these brushes come to the end of their travel while 1½ ins. of the brush is still left. One electrician writes that he has added an extension on one-half of all the springs in the station and transferred the partly worn brushes into a position underneath these springs, giving an additional ⅝ in. wear thereby. This amounts to a saving of nine cents per day.

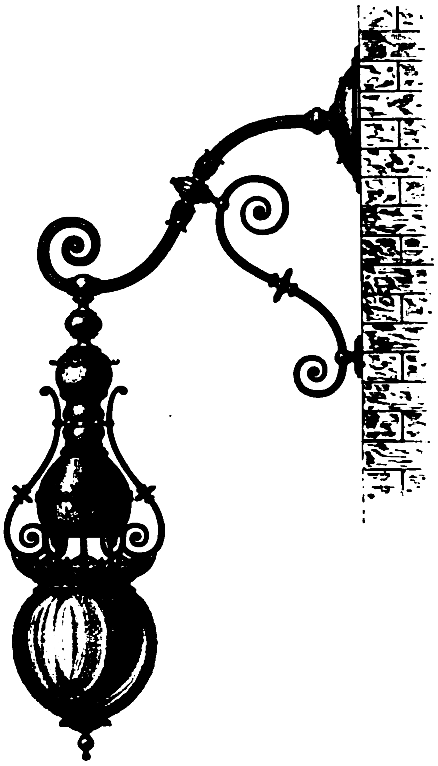


FIG. 15.

In the matter of carbons, the same electrician found that by putting a stop in the upper carbon holder, so as to prevent the insertion of the carbon any further into the holder than is absolutely necessary to make it secure, the irregularities of adjustment by different trimmers can be eliminated and thus the carbons burned to the last quarter of an inch without danger of any lamps being extinguished before daylight by a short supply. With this device is combined a slight reduction of the current after midnight, just enough to keep the double carbon lamps at the normal voltage instead of permitting them to burn high, as such lamps do if the current is kept full during the latter part of the night. The result is an economy of $3 per day in carbons as against the corresponding lighting hours of last fall. The stop appears to be a trifling item, but it secured the certainty of carbons lasting the calculated time.

Where the arc light wires come to the small arm just over the head of an arc lamp and are fastened to the insulators, the wire sometimes breaks. To prevent an open circuit from this cause an engineer in Wisconsin reinforces the wire at this point by joining a piece of wire to the main wire several inches each side of the insulator, making a sort of a bridge or by-pass for the current.

A method for increasing the life of a pole is used in a plant in Illinois. A length of sewer pipe—the cheapest cull will answer—is slipped over the pole about to be set; after raising the pole adjust the pipe so that two inches of it will be above the surface of the ground, and fill in between the pipe and the pole with cement or grout. This keeps the moisture away from the pole. The pipe and cement cost about twenty-five cents per pole.

A rather large station reports that from one o'clock in the afternoon until late in the evening a boy is kept at a dynamo regulator of the incandescent dynamos in order to regulate the pressure on the lamps. The station instruments are not depended upon for this regulation, but pressure wires are run back from the center of distribution of the different feeders, and indicators placed at the end of the pressure wires. Though this is done on Edison three wire systems, but few alternating systems are carrying it out. More than the boy's salary is saved in lamp renewals, from the pressure being kept regular during the heavy burning hours.

On the system of 1000 volts primary and 54 volts secondary, which carries the heavy lighting, two No. 0000 wires are run the length of the block, and this station, having a large transformer of either 150 or 300 lights, is put on each pole and the transformers tied together in multiple, thus displacing a number of small and inefficient transformers. The result is, not only economy in transformers, but ease in running service.

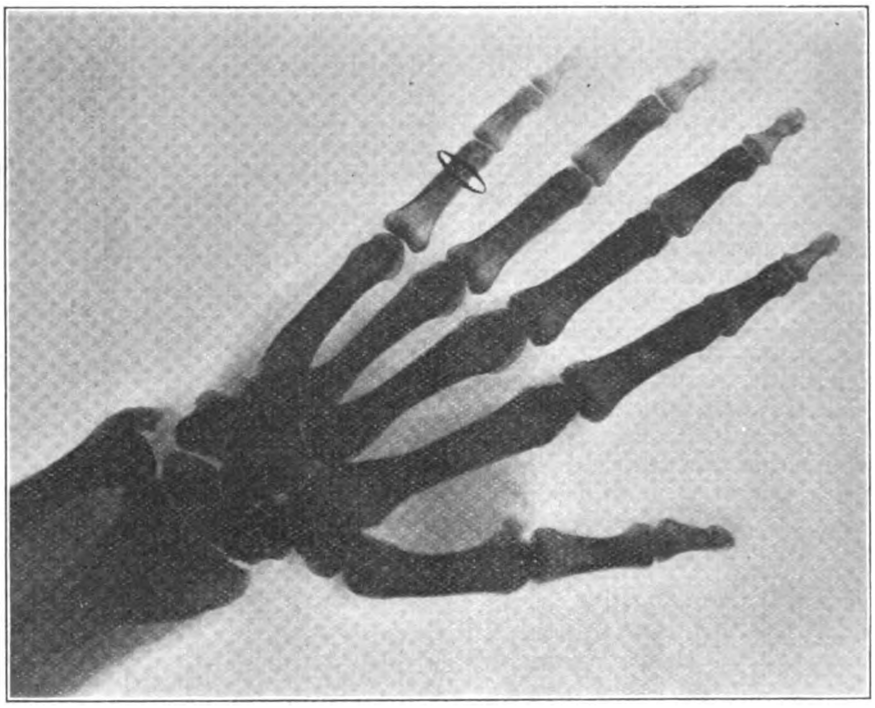
A station of 3500 HP. recommends employing a machinist by the year as Jack-of-all-trades. It has purchased a pair of belt clamps and outfit for $18, and has sent one of its men to a belt manufacturer to learn how to splice belts, etc. It also sent a man to the Thomson-Houston factory, at Lynn, to learn how to wind armatures. A Wheatstone bridge was purchased for testing, and the station is now doing all its repairs, from winding armatures and arc lamp magnets to taking up the slack in thirty or more belts.

RÖNTGEN RAY TUBES.

BY HERBERT B. SHALLENBERGER.

In an article on Röntgen rays, which appeared in the May number of the AMERICAN ELECTRICIAN, it seems to be assumed that the source of the Röntgen rays is the surface of the glass bombarded by the cathode rays, and if this theory is accepted, the writer, Professor Hering, is correct in assuming that the smaller the tube, the more perfect will be the focus. Mr. Edison seems to have accepted this as the correct theory also, and it seems to me rather remarkable that investigators should be led so completely astray from the actual facts as indicated in all the experiments which I have conducted, and as accepted by numerous investigators.

That the Röntgen rays proceed from fluorescent spots on the glass is true in some forms of tubes, but this is true only of such tubes as have diffused cathode rays proceeding from an unfocused reflector and striking against the walls of the tube. Where this diffusion is general and the bulb becomes fluorescent over its entire surface, it will at once be seen that in order to secure anything like sharpness of outline, the tube should be small, since the entire tube is here the source of the rays.



A RÖNTGEN RADIOGRAPH.

But let us examine an entirely different form of tube (see Fig. 1, page 58), such as was described by me as early as Mar. 7, and with which I secured excellent results as early as Feb. 15. This tube is known as the Crookes hot platinum tube, or, since its use in Röntgen ray work, as the focus tube. Here the cathode is a concave reflector of aluminum, which concentrates the Crookes rays on a platinum plate which is either neutral or can be made the anode, the plate being placed slightly beyond the radius of the reflector and in a straight line with its axis. The platinum plate is placed slightly beyond the radius of the reflector for the reason that the Crookes rays converge to the radial point, and from thence proceed in a straight line or beam for some distance beyond.

In this manner the point of focus of the beam on the platinum plate is made more certain and depends for its accuracy on the accuracy with which the aluminum reflector has been made. Beyond the platinum plate in the tube I have mentioned, is placed a small flat aluminum disk which was originally intended to be made the anode plate, thus causing the platinum plate to become neutral, and acting only as a bombarded surface. The platinum bombarded by the focused rays now sends off in all directions the Röntgen rays, and, owing to its great density, and hence its capacity to the Röntgen rays, permits very few of them to pass through, they being radiated from it in all directions toward the cathode reflector. While these rays cause the glass to become fluorescent, the effect is only produced by their passage through the glass, and the glass itself becomes in no way a source of the rays, except to a very small extent as caused by stray Crookes rays. I very soon found that the value of the platinum plate was greatly enhanced by making it the actual anode, and with the tube so connected, I have produced a picture of the hand and wrist in three minutes which showed signs of considerable overexposure, but which was, nevertheless, so sharp that the outlines of the bones showed distinctly where one bone was placed directly over another; the tube in this instance was eighteen to twenty inches from the subject. An engaving of a print from this plate accompanies this article, but the half-tone process employed has failed to reproduce the delicate shadows and sharp outlines of the original. I have tried quite a variety of tubes and have found nothing to compare with this form for sharp, rapid results. Such parts as the knee, elbow, thick part of the foot and so on I have photographed with fine detail in from ten to fifteen minutes.

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

The American Institute of Electrical Engineers held its annual meeting in New York City on May 19 and 20, at which the following officers were declared elected:

President, Dr. Louis Duncan, Johns Hopkins University.

Vice-presidents; Charles Proteus Steinmetz, General Electric Company, Prof. Harris J. Ryan, Cornell University; Prof. Wilbur M. Stine, Armour Institute.

Managers; L. B. Stillwell, Westinghouse Electric & Manufacturing Company; Prof. W. L. Puffer, Massachusetts Institute of Technology; John W. Lieb, Jr., N. Y. Edison Illuminating Company, and F. A. Pickernell, Long Distance Telephone Company.

Treasurer, Geo. A. Hamilton, Western Electric Company.

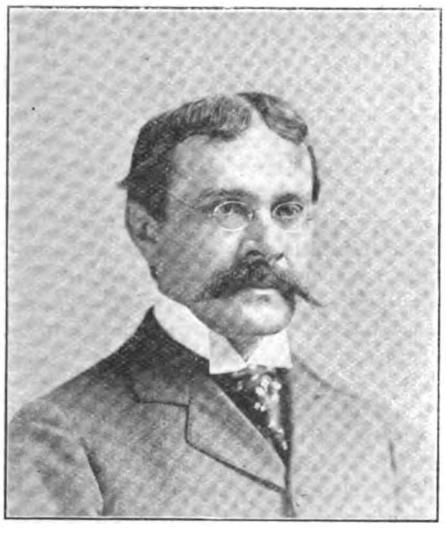
Secretary, Ralph W. Pope.

The hold-over officers are as follows:

Vice-presidents; August Hibbard, M. I. Pupin and W. F. C. Hasson, Managers; A. E. Kennelly, W. D. Weaver, C. S. Bradley, W. B. Van Size, C. F. Scott, B. J. Arnold, Carl Hering and C. T. Hutchinson.

The secretary reported the total membership to be 1035, a gain of 91 over the previous year.

The most important paper submitted at the meeting was a report on "Standards of Light" by Profs. E. L. Nichols, C. H. Sharp and C. P. Mathews, of Cornell University. Seven standards are thoroughly discussed, and the conclusion arrived at that of all, candles are the least reliable, and that the very best way we have at present time of determining candle power is by the Hefner-Alteneck lamp. In this lamp, which is used as a standard in Germany, amyl acetate is the burning fluid.



DR. LOUIS DUNCAN, PRESIDENT A. I. E. E.

Mr. F. J. McKittrick read a paper in manuscript on "An Experimental Study of E. M. F. Induced on Breaking a Circuit,"

Mr. Chas. K. Haguet, in a paper entitled "An Analysis of Transformer Curves," examines into the cause of the distortion in transformer currents. The conclusion arrived at is that such distortion is due, not to hysteresis, but to the variation in the permeability of iron, as first pointed out by Prof. Rowland.

Messrs. Geo. F. Sever, A. Monell and C. L. Perry presented a paper on the "Effect of Temperature on Insulating Materials." The conclusions are that paper is a better insulation and withstands increase of temperature much better than cloth, oiled paper or oiled cloth. That paper and cloth have a maximum insulating resistance, when first heated, at about 140 degs. F. and are not injured mechanically under 360 degs. F. That the point of maximum insulation resistance for paper and cloth depends upon the rapidity with which the temperature is increased, and that both give a high resistance after cooling, but have then little mechanical strength. That it would be well to bake paper and cloth insulation to 250 degs. F. before applying varnish or shellac.

In a paper on "The Reconstruction of the Plant of the Chicago Board of Trade," Mr. B. J. Arnold describes the changes made in an isolated installation whereby a reduction of $10,000 per year is made.

The plant replaced consisted of six boilers operated at a steam pressure of about seventy-five to eighty pounds; five small steam engines in different parts of the building driving several arc and incandescent machines and ventilating fans; and two pumps for four hydraulic elevators. For these were substituted five boilers carrying 125 lbs. steam pressure; two compound condensing engines running at 275 r. p. m., each direct connected to a seventy-five kilowatt direct current generator by means of the Arnold system, which permits either or both generators to be driven from either engine; four Sprague electric elevators; a storage battery of 1000 ampere-hours, and six 10-HP electric motors.

The plant as reconstituted has the total generator capacity available at all times, and allows one engine to be in reserve for repairs, thus doing away with the investment for a third unit, which is usually carried in such plants for safety. The system, when used without the battery auxiliary, is provided with magnetic clutches, which permit the generators to be brought up to speed as motors, and thrown in connection with the engines without stopping either engine. This makes it possible to connect either generator with either engine without shutting down the plant in any part. With such an arrangement, with the engine and generators equal to the maximum capacity of the plant, and with a battery auxiliary equal to one-third the capacity of the plant, any office building can be operated, in the opinion of Mr. Arnold, in the most economical manner, for when the battery is in operating order, one unit in conjunction with the battery handles the plant economically and satisfactorily, leaving one unit in reserve. In case the battery is out of service, both units can be operated until the battery is ready for service again, and during the light load period the battery auxiliary takes care of the entire service of the building, without the use of either the engine or generator units.

METHODS OF STARTING INDUCTION MOTORS.

BY P. M. HELDT.

In starting continuous current, shunt wound motors, a starting rheostat is generally employed, the resistance of which is connected in series with the armature of the motor. By means of a sliding contact piece and contact buttons, this resistance is cut out gradually as the motor acquires speed.

Similarly, in starting up alternating induction motors, a starting device is mostly used. As, according to most prophecies regarding electrical engineering in the future, the induction motor is to have a wide application, a description of some starters applicable to this type of motors may be of interest to the readers of these columns.

An induction motor has two windings, a primary or field winding and a secondary or armature winding. The primary current is supplied from the generator, while the secondary currents are produced by the inductive effect of the primary on the secondary winding. The general practice seems to be to have the primary winding on the stationary, and the secondary winding on the rotating part of the motor, but in the larger motors manufactured by the Westinghouse Company, the arrangement is just the reverse.

First, the conditions that require special means for starting up the motor may be considered.

When the current is turned on the primary of an induction motor with short circuited secondary, the same conditions exist as in a transformer with short circuited secondary. There will result a rush of current into the primary and, consequently, a large drop of potential in the line, which could not be tolerated if lights were supplied from the same circuit. It is for this reason that in some of the latest polyphased installations, the light and power supply circuits are entirely separated.

Besides this, there is the question of starting torque. The maximum starting torque is obtained when the resistance and inductance of the secondary system are equal. In practical machines this relation never exists, for two reasons.

Firstly, in a motor with a secondary winding designed so as to have equal resistance and self-inductance, the loss due to the resistance of the armature conductors would be excessive; or, if this loss or the rise of temperature of the armature, which latter depends on the former, is made to govern the maximum output of the motor, it would have a relatively small output in comparison to its weight. Secondly, such a motor would show a large variation of speed with varying load which, in most cases, is not desirable. The resistance of the armature winding is, therefore, always much less in value than the inductance.

To reduce the generator current necessary for starting the motor and to increase the starting torque, is the object of the starting device. Some of the devices to be described hereafter only decrease the starting current, but do not change the relation between resistance and inductance of the secondary system, and, consequently, do not increase the starting torque corresponding to a given primary current. This class will be considered first.

A resistance or self-inductance (choking coil), connected in series with the primary winding of the motor, would reduce the effective voltage and consequently the primary current. This arrangement is used by the Allgemeine Electricitäts Gesellschaft. The objection to it is that a comparatively large line current is required to produce a certain starting torque.

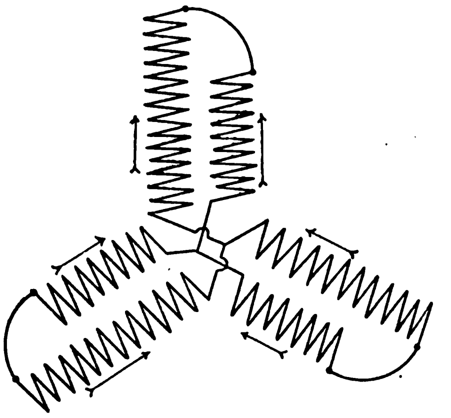


FIG. 1.

A more rational plan seems to be to reduce the voltage of the supply circuit while starting by means of a transformer using a transformation ratio of two or three, so that only about one-third or one-half the current in the primary is flowing in the line. The transformer may be dispensed with if the primary consists of two or more windings, connected in series while starting, and in parallel when running under normal conditions. These methods are in use by several European firms.

We now come to the methods employed to increase the ratio of the resistance to the inductance (or rather reactance) of the secondary system. This may be done either by increasing the resistance or decreasing the reactance. When the armature winding is stationary, as is the case with the larger Westinghouse motors, it is an easy matter to insert resistances in the armature circuits while starting up. Here the resistances are mounted on the frame of the motor and all of them can be thrown in or out of circuit simultaneously by means of a lever. But as the primary winding rotates, the primary current has to pass through sliding contacts. If the armature is the rotatory part, it may be provided with collecting rings, suitably connected to the armature winding. When the motor is started, these rings are connected through non-inductive resistances, but they are short circuited when the normal speed is attained. The starting resistance may also be placed directly on the rotating armature. In this case, the short circuit is effected by means of rings sliding on the shaft. This latter method is employed by the General Electric Company in certain types of induction motors manufactured by it.

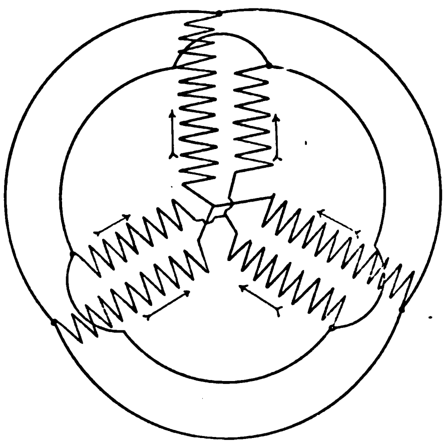


FIG. 2.

An arrangement of armature circuits that admits of reducing the self-inductance of the armature has recently been patented in Germany by the firm of Siemen & Halske. It is based on the same principle, according to which non-inductive resistance coils are wound; that is, a portion of the winding is connected in opposition to the rest. Figs. 1 and 2 show the connections at starting, and under normal conditions. The arrows indicate the direction of the induced E. M. F.'s.

The winding can be so arranged that the change from one connection to another is effected stepwise. For this purpose the smaller portion of the winding is divided into parts and provided with contacts, as outlined in Fig. 3. Provision should be made to connect the upper ends of the smaller portions of the winding while the slide moves on the lowest contact point.

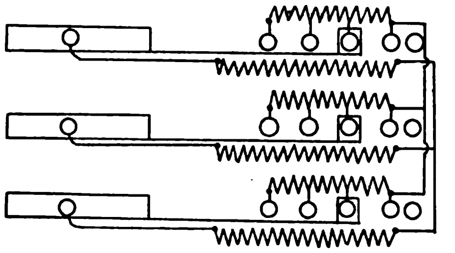


FIG. 3.

There is another method of changing the phase of the secondary current, which consists in introducing an external E. M. F. into the secondary circuit. This E. M. F. must be alternating and have a certain phase relation to the current flowing. The periodicity of the currents generated in the secondary of an induction motor is proportional to the slip. If then these currents be led into the primary of another motor having its rotating part on the same shaft as the former, the speed of this motor will be very nearly proportional to the slip of the first motor. But the speed of the two motors must be the same, as both have a common shaft. If both motors have the same number of poles, the slip will be about fifty per cent. A starting resistance is placed in the secondary of the second motor while starting. In the case where the secondary of the first and the primary of the second motor are rotating, no sliding contacts are required. This combination, although rather expensive, has the advantage of nearly constant speed for all loads. A machine of this description of about forty horse power has been built at the Siemens & Halske works, and is operated successfully in a mine.

Still another method of shifting the phase of the secondary currents is to close the secondary circuit through condensers. The capacity of the condensers neutralizes the self inductance of the armature. Here the self inductive effect of the armature is reduced without lessening the number of effective armature conductors. It is the ideal method for obtaining large starting torques, but first cost considerations would appear to render it impracticable at the present time.

In small motors, where a few per cent of efficiency may well be sacrificed for the sake of simplicity of construction and operation, it is the usual practice not to use any starting device, but to design the armature so as to have a relatively greater resistance.

POLYPHASED WORKING.

In a paper read before the recent National Electric Light Association, Mr. W. L R. Emmet stated that the first three-phase apparatus made in this country was put in operation two and one-half years ago, and since then the company which furnished this has put in operation 33,500 HP capacity in three phase generators; 10,000 HP in three phase induction motors; 14,800 HP in monocyclic generators; 6000 HP in three phase synchronous motors; 10,560 HP in rotary converters, and 42,000 HP in transformers used for power purposes, the average capacity of the latter being sixteen horse power, and the largest having a capacity of 1100 HP. Different methods of distributing power and light by alternating currents were illustrated by diagrams showing the connections used with each.

Fig. 1 shows a three phase system as ordinarily applied to the transmission of power for lighting and other purposes over long distances. The generator may be of any convenient voltage since step-up transformers are used. These transformers are in three units or groups, two of these units being available to transmit a large proportion of the power in case one is disabled. Two sets of step-down transformers are shown, one supplying 1000-volt distributing lines and the other supplying a system of four wire secondary mains. With a given lamp voltage such mains give a slightly better copper economy than the ordinary three wire system, and afford an excellent means of secondary distribution. Such a system as is illustrated in this diagram, it was stated, will give excellent service in almost any town, the low tension mains taking care of the thickly built up portion, and carrying the bulk of the lighting load, while the high tension distributing system covers all outlying portions and operates large power units. A number of large plants has been installed within the last two years, using the three phase system as here shown.

Fig. 2 shows the connections for distribution by the monocyclic system. Here all lights are connected single phase between a single pair of conductors leading from the generator, the motors being operated from the same single phase circuit in combination with a third conductor leading from what is known as a "teazer coil" on the generator. Here the simple three wire system is used for secondary distribution, and if it is desired to connect motors to the lower tension mains, a supplementary transformer is used, which supplies a secondary teazer wire; to this and the outside wires of the three phase system the motors are connected. The great merits of the monocyclic system as stated are, that the number of conductors required for lighting and power distribution is reduced to a minimum, and that no unbalancing is possible. The operation of three phase motors from this system is in all practical results the same as when they are run from three phase circuits.

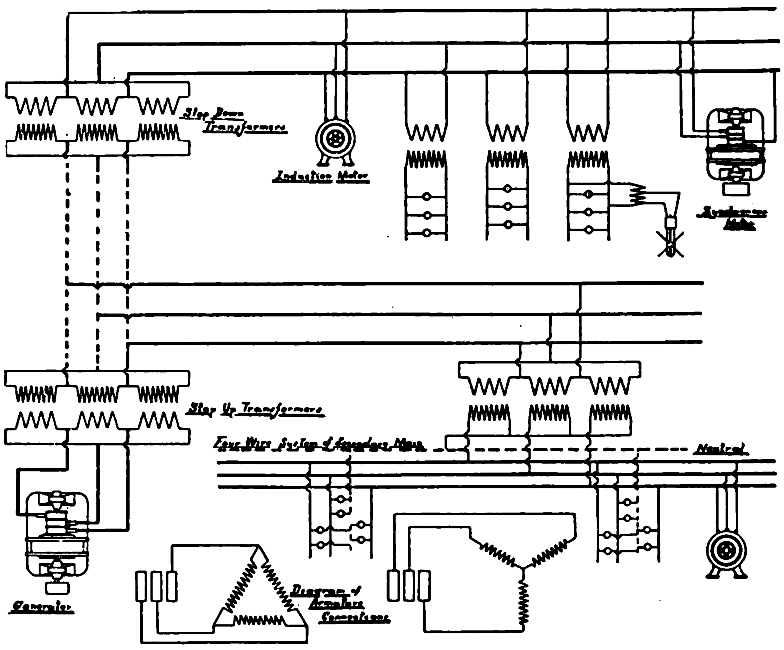


FIG. 1.—THREE-PHASE D SYSTEM.

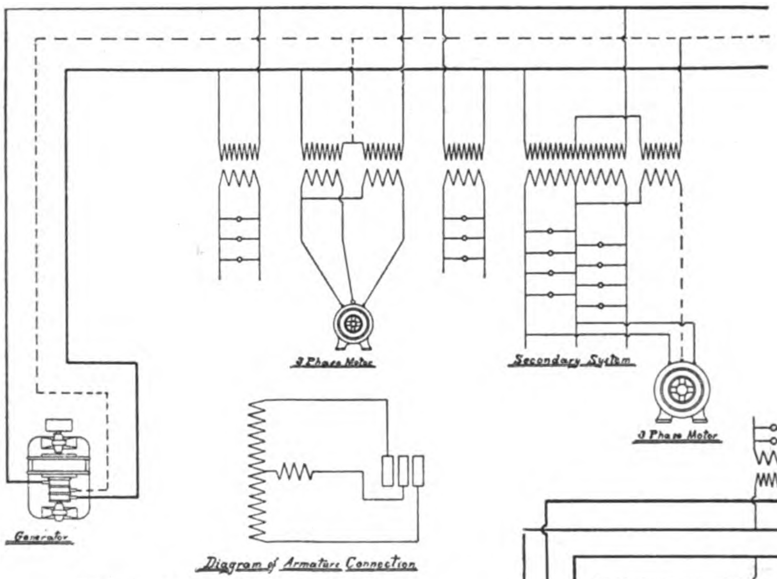


FIG. 2.—MONOCYCLIC SYSTEM.

Fig. 3 shows the connection of the two-phase system, with distribution by four conductors. Here the lighting is divided between two separate circuits which must be kept balanced within certain limits, depending upon the regulation of the generator or the amount of care that can be given to the adjustment of pressure on the different sides. Where motors are run, the two circuits must be brought together. The two-phase, four-wire system can be operated either from a generator with two independent circuits, or all four conductors can lead from one armature winding.

Fig. 4 shows the two-phase, three-wire system which has been used to some extent for both high tension distribution and for distribution by secondary mains. The principal advantage in this system is that it requires one less conductor than the four-wire two-phase system. Its disadvantages are that the insulation of the apparatus is subjected to a voltage forty-two per cent higher than that which is available in transmission, and that the self induction in the lines and transformers causes an unbalancing of the voltage on the two sides of the system, accompanied by a distortion of the phase variation.

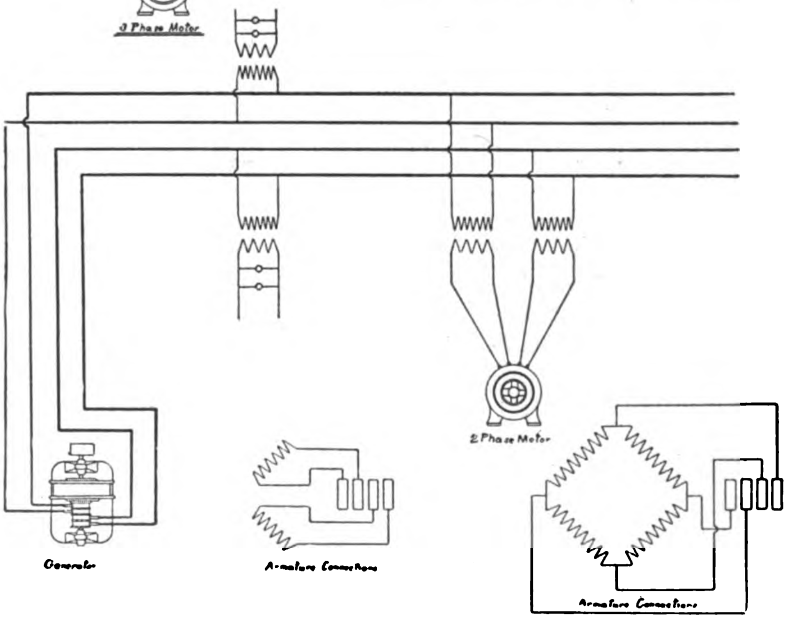


FIG. 3.—FOUR-WIRE, TWO-PHASED SYSTEM.

In the discussion of Mr. Emmetts paper, Mr. Van Trump said that he was operating a two phase system with a synchronous motor driving Edison generators on a three-wire system, and the system works beautifully with only one exception—with a perfectly steady and even load on the Edison generators and no fluctuation whatever in their speed, there seems to be a slight fluctuation on the alternating mains as though the motors tended to get out of synchronism, which, however, they never do.

Mr. Emmet ascribed this effect to the variation in speed of the prime mover, such a variation tending to pull the motor out of step. Every time the generator varied the least bit in speed, it would tend to pull out, and in so doing would cause a variation in the voltage.

Mr. Scott, in reply to a question by Mr. DeCamp, said that large transformers supplying a number of customers would in general be more economical than a number of individual transformers. The cost of secondary mains from the larger transformer may, however, be prohibitive if the district is a very large one. In general Mr. Scott believes in the use of secondary mains with alternating systems, and thinks that this will be found most economical aside from very exceptional cases. Mr. Scott also referred to the measurement of power on polyphase systems. A three-phase system, he said, is so interconnected that without extended or elaborate measurements, it may be impracticable to determine the load, whereas, on the two-phase system in general, the amount of power measured directly in one circuit, added to the amount of power measured directly in the other circuit, will give the total power, if the conditions are normal. For this and other reasons, the two phase system with independent circuits seems to Mr. Scott to be the best arrangement.

Mr. Scott described a method of secondary distribution, which he thinks has a future before it, consisting of a three-wire system, but with only two wires running from the central station. In this case a 200-volt circuit might be used as secondary mains, and two connections made to a customer. On the customer's premises would be a balancing coil with a single winding adapted to 200 volts, the two ends of the coil being connected to the 200-volt circuit, and a loop brought out from the middle of the coil, between which and either of the secondary mains there would be a voltage of 100. This coil would serve to preserve a balance between the two circuits, so that should the number of lamps be greater on one circuit than on the other, the E. M. F. would be practically balanced.

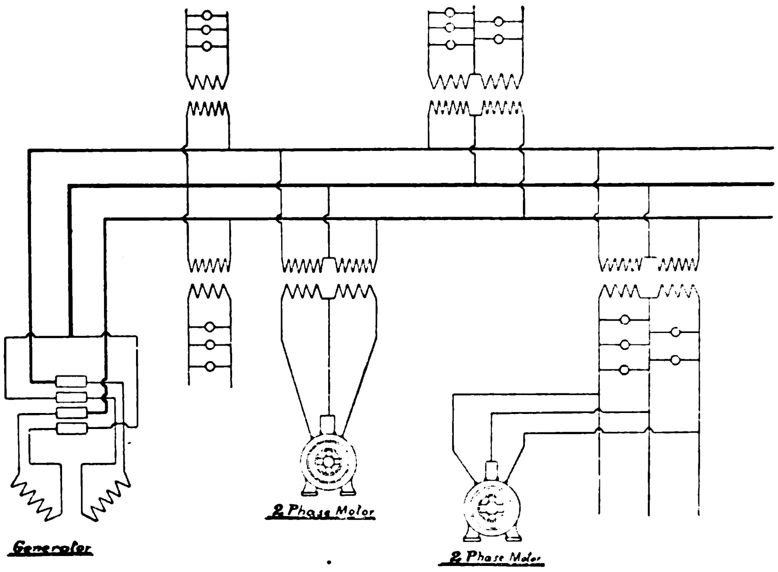


FIG. 4.—THREE-WIRE TWO-PHASED SYSTEM.

Mr. Wagner spoke of a series alternating arc system which he has now in use, whose circuit is similar to that used in series arc lighting; he is now operating as many as seventy-five alternating current arc lamps on one transformer and this does not seem to be the limit.

Mr. Dow stated that at present series alternating arc lamps can be made to work as well as old series direct-current lamps.

TESTING IRON AND STEEL FOR MAGNETIC QUALITY.

In a paper recently read before the Chicago Electrical Society, Mr. W. K. Howe gave an interesting description of the various practical methods which have been devised for testing iron and steel for magnetic quality. As these methods illustrate in concrete form some of the principles of magnetism, including hysteresis, we abstract the following descriptions.

In Fig. 1 is shown an instrument devised by Ewing for measuring hysteresis. It consists of a permanent magnet, *N*, *S*, pivoted on a knife edge, between the poles of which the specimen of iron to be tested, *S*, is rotated, the specimen in this case being a number of pieces of armature disk iron. The sample is rotated by hand by means of a large friction wheel which gears with a smaller one on the shaft, *n*. The speed of rotation is a matter of no particular importance, providing it is not so slow that the readings are unsteady. The principle of the apparatus is as follows: When the end, *P*, of the sample appoaches *N*, it becomes magnetized by lines of force from *N*, and therefore tends to attract the end of the magnet to it. As it passes away from *N* it, of course, continues to attract the permanent magnet, but in an opposite direction. Owing, however, to the lag of magnetism, that is to say, to hysteresis—*P*, at any point to the right of *N* has a stronger magnetism than at a corresponding point to the left of *N*; consequently, when *S* is rapidly revolved, *N*-*S* takes up a permanent deflection on the side toward the stronger magnetism, the amount of which is indicated on the scale at *T*. Standard samples of iron of known quality are supplied with the instrument, and the actual loss in a given sample tested is determined by comparison with this standard.

In Fig. 2, is shown an instrument originally designed by Prof. S. P. Thompson and modified by Kapp. The specimen, *S*, to be examined is firmly held in the top part of a massive soft iron yoke, *Y*, and has its lower end faced up truly and held central by the brass collar, *C*. Below the specimen is a small soft iron plunger, *P*, which is guided at both ends. Its upper end is faced true and is held against the specimen, *S*, by magnetic attraction, and to its lower end, *W*, is fastened a scale pan for receiving weights. The operation of testing is as follows: A certain measured current is sent through the magnetic coil, *a*-*b*, and weights are then added until the plunger is pulled off. From the area of contact at *J*, and the total weight of the plunger, scale pan and weights, the number of lines of force is easily calculated, being the square root of the quotient of the weight in pounds by the cross section of the specimen in square centimetres, multiplied by 3345—this giving the number of lines per square centimetre. In practice, a curve is plotted in terms of lines of force per square centimetre or square inch, and of the corresponding pounds to detach the plunger, from which, with a given specimen, the data required may be found from the curve when the detaching weight is determined.

Fig. 4, shows an instrument designed by Mr. L. T. Robinson for making tests for either hysteresis or permeability. The specimen, *S*, is held by suitable clamps in the two massive pole pieces, *Y Y*, which embrace an armature around which is wound in a longitudinal direction a coil, *C*, of fine wire. When a current is passed through a coil, *a*-*b*, on the sample to be tested, the pole pieces *Y*, *Y*, are magnetized, and the armature, *C*, is deflected more or less according to the number of lines of force generated in *a*-*b*. Once standardized, by substituting any bar of the same section as *S*, and with the same current in *a*-*b*, the magnetic value of the material of the bar may be determined.

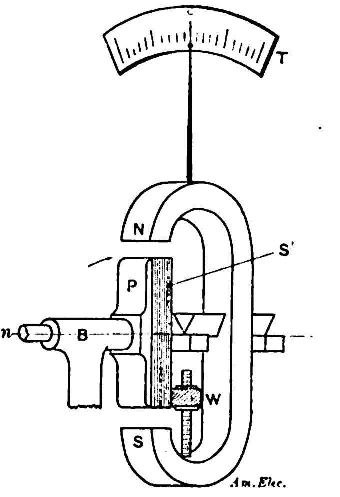


FIG. 1.—EWING HYSTERESIS APPARATUS.

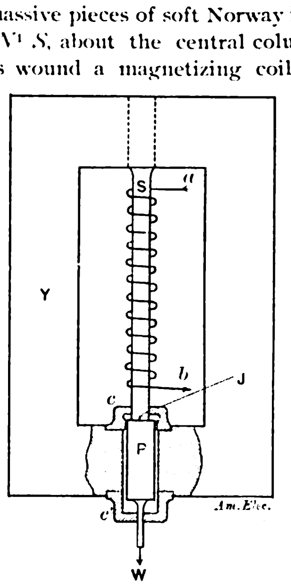


FIG. 2.—THOMPSON-KAPP PERMEABILITY METER.

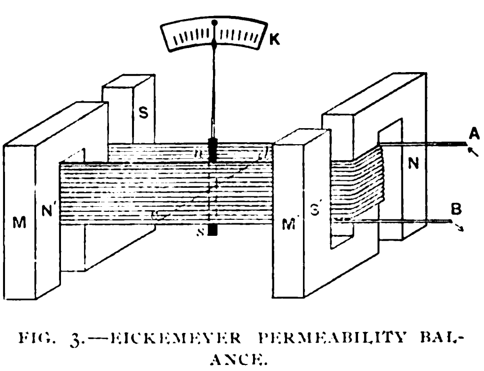


FIG. 3.—EICKEMEYER PERMEABILITY BALANCE.

In Fig. 3, is shown an apparatus devised by the late Rudolph Eickemeyer for testing the magnetic qualities of iron. It consists of two massive pieces of soft Norway iron, *N* S^1 and N^1 *S*, about the central columns of which is wound a magnetizing coil, *A*-*B*. In the middle of the coil is a soft iron needle, *N*-*S* with an aluminum indicator, which plays over a vertical scale, *K*. When a current is passed through *A B*, the indicator normally remains in a vertical position through the influence on the soft iron needle of the coil alone; for, the influence on the needle of the lines of force which proceed from S^1 to *N* is neutralized by those also proceeding from *S* to *N*. If, now, an iron bar is laid against the side, *M*, M^1, the lines of force on that side are shunted, and those proceeding from S to N on the opposite side cause the needle to be deflected. In practice, the bar to be tested is placed against, say, the sides $M M'$, and standard iron bars of smaller section are then placed against the side of N-S until the needle returns to zero. When this occurs, the two magnetic shunts are of the same value, and by comparing the sum of the sections of the standard bars with the section of the iron being tested, the comparative magnetic value of the latter is found.

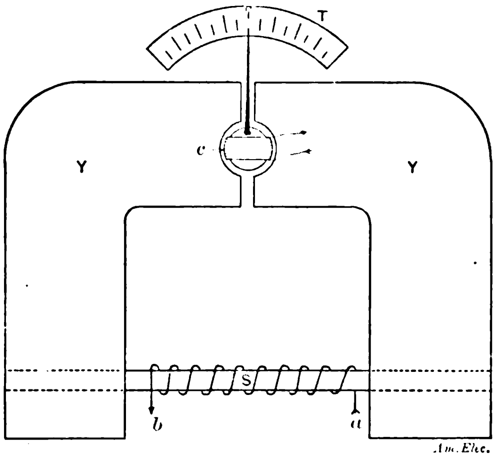


FIG. 4.—ROBINSON PERMEABILITY METER.

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Electric Motors. The diversity of uses to which electric motors are now being put is explained by a list recently published, enumerating the orders received in two weeks by a single company. Motors were called for to operate printing presses, saws and planers in a box factory, an assortment of mining machinery in a coal mine; machinery in a large bakery; blowers in a stove works; a fire pump; a mine pump; large arc lighting dynamos; a jib crane, traveling cranes; machinery in an oilcloth works; inclined railway etc., etc.

◆

Electric Power Transmission in Canada. The Lachine Rapids of the St. Lawrence are to be utilized and their power turned into electricity. For some time past work has been carried on by the Lachine Rapids Hydraulic Company, upon a large wing dam which runs out for more than a thousand feet into the St. Lawrence River. A fall of water is secured by means of this dam, sufficient to develop at the low water season 15,000 HP. Upon the dam a power house will be built, which will run its entire length and show an unbroken interior of 1000 ft. long. The basement of this will be occupied by the water and the main floor will contain the dynamos, of which there will be twelve General Electric machines, each of 1000 HP or 12,000 HP in all. They will be of the polyphased type and will generate current for transmission to Montreal for use there in lighting the city, operating the street railways and for lighting and power purposes. The contract for this electrical installation is the largest ever placed at one time for electric dynamos. It is also worthy of note that, although it was competed for by every prominent electrical manufacturer in the world, the superiority of the American apparatus kept the order with home manufacturers.

Tesla on Marriage.—During a recent interview Mr. Tesla was asked if he believed in marriage for persons of artistic temperament. In reply he said that for an artist, musician or writer, yes; but for an inventor, no. The first three, he said, may gain inspiration from a woman's influence and be led by their love to finer achievement, but an inventor, he believes, has so intense a nature "with so much in it of wild, passionate quality" that in giving himself to a woman he might love he would give everything, and so take everything from his chosen field. He does not think that many great inventions can be named that have been made by married men.

◆

Telegrams Extraordinary. During the Electrical Exposition, one of the events was the sending of a telegraphic message by Dr. Chauncey M. Depew to Mr. Edward D. Adams (who was in the exhibition hall) *via* the Pacific Coast, Nova Scotia and London. The message was transmitted by Pres. A. B. Chandler, of the Postal Telegraph Company, and received upon its return by Mr. Edison, the time elapsed being four minutes. Only one relay, at San Francisco, was used in the land transmission. An answer from Mr. Adams followed the same course. The following is the message sent by Dr. Depew:

> God creates, nature treasures, science utilizes electric power for the grandeur of nations and peace of the world.

Not to be outdone in telegraphic composition, Mr. Adams returned the following reply:

> Mighty Niagara, Nature's work, serving man, through the world's electric circuit proclaims to all peoples, science triumphant and a benevolent Creator.

◆

Electricity in the Household and Hospital.—Among the numerous applications of electricity, as recently illustrated at the Electrical Exhibition in New York, is a modern method of producing heat by electricity for household and hospital service, and in such a way as will appeal to many an individual "under the weather" and to the medical profession generally. Advantage is taken of the heating effect produced by the passage of a current of electricity to construct a flexible, fire-proof mat or pad of asbestos, in which are concealed conducting wires, the appliance thus formed being utilized in making the local applications of heat heretofore effected by the hot water bag, compress, soapstone or brick. It has been the experience of most poor mortals at some time or other to wrestle with the elusive water bottle and suffer under its extremes of temperatures. The device referred to is so simple and effective that after the first "hurry call," the nurse can cease her periodical wanderings after hotter water and the patient be permitted to nurse his pain in peace. It must happen that the beneficial effect of a "local application" is often lost or retarded by the necessity for frequent renewals of the water bags. The "electrotherm," for that is the name of the new heating pad, necessitates no such changes, and a constant temperature can be maintained indefinitely. In prolonged or acute cases of rheumatism, pneumonia or the good old fashioned stomach ache, the electrotherm should prove a relief alike to patient, doctor and nurse. All that is necessary is to connect the flexible cord which accompanies each pad to the ordinary electric fixture and regulate the temperature by a simple little switch provided for the purpose. We understand that the electrotherm has supplanted older means in many instances, and has most satisfactorily proved its efficiency and convenience. Ordinarily it is furnished with a felt or flannel cover, in which form it is suitable for many purposes, and it is also covered with rattan for use as a foot warmer, for warming beds, dishes and food. It is such a clean, convenient and sensible device that we may soon expect to find it in all households so fortunate as to be provided with electric service.

◆

X Ray Foolery. Two Chicago professors have put forth a theory that Röntgen rays will kill disease germs, and the following is the argument they offer in its support: "The magnetic force from the X rays will pass directly into the affected tissues, electrolysis being the result. The chemical decomposition liberates the oxygen, which unites with the free oxygen of the body and produces ozone. It is in reality this ozone which does the work, as it is guaranteed to kill every particle of bacteria the body may at that time possess." Unfortunately for this theory, Röntgen rays do not possess magnetic force; if they did, magnetic force could not cause electrolysis; if electrolysis took place, it does not follow that the oxygen liberated would remain free; if it did pass beyond the nascent state, it would not combine to form ozone, even if there was "free oxygen of the body" for it to combine with. Why any oxygen released by electrolysis should not in itself form ozone instead of seeking for the "free oxygen of the body," "Professors" Pratt and Wightman (the theorists in question) do not explain.

Another theory in regard to "X rays" has been advanced by Professor Daniel, of Vanderbilt University. A Röntgen tube was kept a half inch from a patient's head for an hour in an attempt to obtain an "X radiograph," and several weeks later the spot on the head opposite the piston of the tube became bald. Professor Daniel thinks this incident may bear a suggestion as follows: "X rays are yet unexplained; Professor Röntgen believed them to be longitudinal vibrations; it is difficult to distinguish a longitudinal deplacement of the ether from an electric current "as far as it goes" (whatever this qualification may mean); sending an electric current to the roots is a well known method of exterminating hairs. The conclusion is both cautious and ambiguous: "If any such quasi-electric current has resulted from the X rays, the effect upon the hair might be thus accounted for."

The above theories recall one advanced concerning "universal electricity," as follows: "As all the surrounding worlds are probably heterogeneous, doubtless nebulae and most of the meteors and comets, are also charged with electricity. Those bodies which are not heterogeneous are doubtless charged by radiant electricity from other bodies. Thus it is logical to infer that the whole universe is vibrating radiant electrical waves."

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Hysteresis.

The form of hysteresis tester, described in another column, very plainly illustrates the principle of hysteresis or magnetic lag. Notwithstanding the rather formidable name, this phenomenon is a simple one, and, moreover, one of considerable practical importance in the making of electrical machinery. In order to overcome the resistance of magnetism to be reversed, energy must be expended. If the iron resists strongly, considerable energy may be required, which will reappear in the form of heat in such quantities as to give the apparatus a higher temperature than it can safely bear.

In a recent instance, sheet iron for the armature disks of a motor of a special design was purchased from the usual stock of a hardware dealer and used in the construction of an armature. When the motor was finished and tried, an alarming degree of temperature was soon attained, and it was seen that the machine could not be used. The designer, of course, was held responsible and accused of not knowing his business. Upon investigation, he discovered that the cause was hysteresis, as the armature became as hot when turned by belt as when run by current.

Compressed Air Motors.

The Metropolitan Railway Company recently arranged to have a few street cars, ten or twelve in number, fitted with compressed air motors for trial, and the result has been a slight scare in street railway circles—perhaps due more to the mysteriousness with which the "new" motor is surrounded than otherwise. As the compressed air motor has been in existence almost since the steam engine, it is little likely that at this late day revolutionary discoveries have been made concerning the utilization of this type of fluid engine.

Before the day of electric traction, compressed air apparatus was repeatedly tried for street traction, but in no instance, in this country at least, was it able to compete with the horse or mule as motive power. Even were it untried, the principles involved in the utilization of compressed air have for fifty years or more been as well known as those relating to steam, and, therefore, there is little room for belief in any startling innovations. In recent years compressed air has been used on a French street railway, apparently with satisfaction, but this has not led to its adoption elsewhere in Europe, where electric traction, as in this country, has had a clear field.

Polyphased Working.

The abstract in another column of a paper read by Mr. W. L. R. Emmet before the recent National Electric Light Convention, will be found of interest, particularly on account of the very complete diagrams which it contains of different polyphased circuits. Of these, the two-phased system is represented with both three-wire and four-wire circuits. It may be well to repeat here that in the former case, the third wire corresponds to the common return of a continuous current circuit, while in the three-phased system each of the three wires in turn acts as the "return" for the other two. The fours-wire system consists of two distinct simple alternating circuits, neither differing in any respect from any two ordinary circuits from separate alternators. It is only when the two currents are used in combination to develop magnetism that unusual consequences follow.

It is an interesting fact that about the first alternating currents extensively used in electrical lighting were generated from what were polyphased machines. The machines made by Gramme for use in Paris with Jablachkoff candles contained a number of separate circuits so wound that the currents produced differed in phase—the different currents supplying separate series of lamps. It was not, however, until the discovery of the principle of the rotary field, which was independently made by Tesla and Ferraris, that the vital importance of difference of phase was appreciated.

Alternating Currents.

The article in another column by Lieut. Patten on alternating currents will be found instructive through bringing out clearly and in simple language the relation to each other of the several different kinds. It is shown that at the same time, a direct current and single, two-phased and three phased alternating currents may be taken from the same machine. Moreover, the method described by which this may be done is so simple and so inexpensive of application, that almost any of our readers will have opportunities to test it practically. The article will perform a good office if it serves to dispel the mystery with which the nature of alternating currents in general unfortunately still continues to be surrounded.

The ordinary direct-connected dynamo is, in fact, an apparatus which generates alternating currents of many phases, the simple alternator and two and three-phased machines being, in principle, merely simpler forms of that apparatus. If a dynamo has, for example, a 72-part commutator, it generates thirty-six alternating currents, each reaching its positive or negative maximum one-thirty-sixth of a revolution behind the current in advance. Any two adjacent bars of a commutator correspond to the two rings of an alternator, and, as shown by Lieut. Patten, by making continuous connection with certain other bars, two and three-phased currents can be procured. The function of the commutator, one of the greatest of electrical inventions, is to rectify and then add together the numerous alternating currents of different phase, thereby producing and delivering a continuous current.

Optical Efficiency.

As light is a form of energy, its efficiency, with reference to the energy from which it is generated, admits of calculation if the data are at hand. If the light is that of an incandescent lamp, by measuring the amount of electrical energy supplied in a given time and the amount of heat given off in the same time, the difference will give the amount of energy transformed into light. It has been found that but from three to five per cent of the energy supplied to an incandescent lamp is transformed into light, and but ten to fifteen per cent in the case of the arc lamp. In other words, while an efficient 16-CP incandescent lamp of the present day consumes fifty watts of electrical energy, but from 1.5 to 2.5 watts are transformed into light, the remainder being wasted and appearing in the obnoxious form of heat at the lamp.

The field thus offered for improvement is the greatest and most tempting in the entire range of science, and the inventor who succeeds here will have a royal reward. The difficulties in the way of improving optical efficiency are, however, of the gravest character. Besides, a solution consisting in producing light at a higher optical efficiency, would not necessarily solve the problem as far as illumination is concerned, for the character of the light has also to be considered with reference to the human eye. Any light, therefore, departing widely from the standard which is thus set, such as in an excess of actinic rays, might be useless. For this reason it is questionable if the efficiency of the incandescent lamp can be carried to a very high degree, for this involves a greater proportion of actinic rays, which are harmful as well as disagreeable to the eye.

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Electric Lamp Globes.

In another column Prof. Shepardson points out a number of considerations that apply in the selection of lamp globes, which is a subject to which usually little attention is paid. As will be seen, two efficiencies enter, which are in a sense antagonistic—the one relating to the utilization of the light emitted by the source for illumination, and the other to the character of the illumination. To the latter a sacrifice of from twenty to sixty per cent of light is usually made, and even the clear glass globes, which merely protect the source of light, may involve a loss of twenty per cent. With such great losses at the receiving apparatus, it would seem that some of the thought spent on attempts to attain a few per cent. more efficiency at the generator or, with alternating currents, at the transformer, might with profit be devoted to producing a more efficient lamp globe. Recently several forms of globes have been inintroduced on the market which, though made of clear glass, give a diffusing effect similar to that obtained with opal and ground glass globes. The diffusion of the light in this case is caused by corrugations, both internal and external, and, it is claimed, with a very small loss through absorption, or, in other words, through the change of light into heat rays.

Prof. Shepardson refers to a compensation for the loss of optical efficiency through the use of translucent globes, which comes from the fact that the iris of the eye opens wider on account of the reduced intensity of the rays, so that one may actually see much better than if the light were stronger. This is the cause of the paradox that, at least in small interiors, visibility is increased when clear glass incandescent lamps are replaced by frosted lamps, though with the latter a large percentage of the light is wasted by absorption. The photometer thus is not the true measure of light efficiency, and as the actinic components in light increase through the incandescent filament being heated to a greater intensity, the spectroscope may probably be called into use to modify the indications of the former apparatus.

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Steam Engine Efficiency.

Much has been written concerning the variation of the efficiency of the steam engine with changes of load, but we know of no contribution to the subject in which present knowledge on the subject is summed up as clearly and concisely as in the article in another column by Prof. Durand, director of the School of Marine Engineering at Cornell University. Though necessarily somewhat general in its treatment, the reader, by reference to the curve representing the type of engine in which he is interested, can confine his attention to that more particularly, and it would be well worth his while to compile from it a table of the variation of water consumption with various loads above and below the normal, as such information will not come amiss in practical working.

When compound engines were first used in electrical generation, much was said about their great inefficiency under small load, and it was argued that the case would be even worse with triple expansion engines. By reference to the curves of Prof. Durand, which are all compiled from practical engine tests, it will be seen that actually the reverse is the case, the multiple expansion engines being better adapted for variable load than simple engines. The cause of the contrary belief was probably two-fold. First, it is only comparatively recently that the various losses between the coal pile and the electrical receiver have been separated in determining plant efficiencies; when changes from simple engines were first made, it is probable that attention was also then given for the first time to the taking of economy data. This situation, therefore, naturally led to erroneous interpretations and comparisons. Second, it is not yet clearly understood that the economy of the several types of engines cannot be considered without reference to the pressure at which they are used. To each type there corresponds a pressure at which it is most efficient, and therefore, it is not surprising that those who have replaced compound with triple-expansion engines without change of pressure, should become skeptical in regard to the claims for high efficiency made for the latter type. The economy comes from the number of expansions used, and the larger the number of expansions the higher the initial pressure. As both experience and theory have shown that but a limited number of expansions can be economically made in one cylinder, the necessity therefore arises of dividing it into two or more stages, whence compound and triple expansion engines.

The remarks of Prof. Durand concerning the size of engine units are in line with current opinion as to under-loading. The price between one size of an engine and another a size or two larger is so comparatively small that the temptation, in view of a probable increase of plant, is very great to purchase the larger size, but in many cases, particularly where coal is expensive, a resultant loss instead of a gain results. The conditions in this respect, however, are complicated, for while the undesirability of under-loading may be recognized, in addition to the consideration mentioned above, questions of space occupied and electrical efficiency enter, and in the end, when working at its normal capacity the larger engine will have a higher efficiency than its equivalent in smaller units. As it is shown that an engine works with better economy on an overload than on an underload, this fact is one that should not be forgotten when the question of adding an additional engine comes up. Any good engine should stand a moderate overload without ill consequences, particularly if it is one which is rated at the power corresponding to its maximum efficiency.

A RÖNTGEN RAY OUTFIT—II.

THE VACUUM TUBE AND FLUOROSCOPE.

While a Crookes tube cannot be conveniently made, as can the other essential portions of this outfit, considerable care must be taken in selecting one for purchase, and a few hints will be useful to the uninitiated. It must be borne in mind that the Röntgen ray is as yet an unknown quantity, and a day's discovery may contravert all the hints here given. However, science is now obtaining the best results with tubes that conform to the following general conditions:

The tube must be of the thinnest glass available, and sufficiently strong to withstand the mechanical stress due to the pressure of the atmosphere. Thick glass when used in Crookes tubes heats to a very high temperature, and if the tube is forced, it frequently gets red hot under the influence of the discharge. By experimenting with tubes having both thick and thin walls, it was found that thick walls were heated to melting while the thin walls remained quite cool. A thick wall is more strongly fluorescent than a thin wall, but is greatly inferior to it in radiographic power. For this and other reasons, it is very doubtful if the intensity of the fluorescence of a Crookes tube is a criterion of its excellence as regards its ability to generate Röntgen rays.

The size of the tube is an important feature. If sharpness of detail is particularly desired, the smaller the tube the better. In fact, some of the best results have been taken with so-called "perfect vacuum" tubes. These tubes were primarily designed to demonstrate the fact that a perfect vacuum is also a perfect insulator. A small tube, with two terminals a few millimeters apart, is exhausted to the highest degree of vacuum attainable by any known means. This tube, when placed in circuit with a powerful induction coil, presents such a high resistance to the discharge that the latter prefers to strike around the outside of the tube rather than to pass through the interior. This very prettily shows the principle the tube was intended to demonstrate. This tube, however, has the property of generating Röntgen rays when excited by an ordinary induction coil, and as it is very small it casts an extremely sharp shadow, for a precisely analagous reason to that which accounts for the sharpness of the shadow cast by the ordinary arc light. The short distance between the terminals of this tube permits the use of a correspondingly small induction coil, and it is, therefore, a desirable tube for those who cannot afford apparatus as powerful or elaborate as that described in the last article. Up to date there is no particular advantage in a large Crookes tube. Small ones when properly excited seem to give just as powerful emanation of Röntgen rays, and have the advantage of giving a clearer definition.

The shape of the tube is of as great importance as the size, and technical discussion is now rife as to which is the best. The latest theory of the source of the Röntgen rays is that they emanate from the surface or surfaces that are first impinged upon by the cathode rays, or rays proceeding from the negative pole of the Crookes tube. This generating surface may be, and indeed often is, the anode. For this reason several eminent authorities were deceived into stating that the anode was the source of the Röntgen rays. This, it will be seen, in the light of what has just been said, is only true in certain cases. A metal surface seems to be a more powerful source of Röntgen rays than a glass one when subjected to a cathode bombardment, and of the metals platinum appears to be the best.

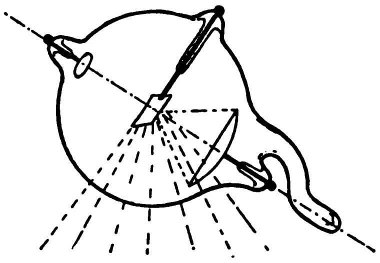


FIG. 1.

The metal in this case does not reflect the Röntgen rays. It is, instead, the source of them. This fact was discovered through a very fortunate circumstance. Crookes, in showing shadow effects, constructed tubes with a shield of metal mounted in the tube, as shown in Fig. 1. Pictures taken with such tubes were wonderfully sharp and distinct, and subsequent investigation developed the cause. Mr. Herbert B. Shallenberger, who was, perhaps, the first to produce Röntgen pictures of marked perfection, undoubtedly owes his success to the fact that among other favorable conditions he employed a Crookes tube of this type, slanting it, as shown, for best distribution. Therefore, it is well to select this type in preference, provided that it otherwise fulfills the requirements.

Now that Crookes tubes are being made specially for Röntgen photography, tubes of this type are to be had which are a decided improvement on the old Crookes form for demonstrating the theory of luminous shadows. Such a tube is shown in Fig. 2. Prof. Elihu Thomson has gone so far as to suggest that such a type be made standard. Mr. A. A. C. Swinton has employed the tube shown in Fig. 3 with great success. Professor Thomson's type and that of Mr. Swinton, it will be noted, differ only in detail.

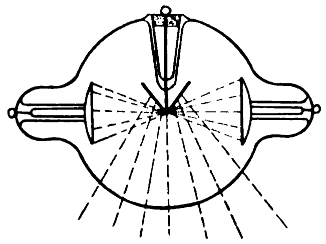


FIG. 2.

The mode of connecting this kind of tube varies with the source of electrical power employed. An induction coil discharge is practically a pulsating discharge always in the same direction, as explained in an answer to a query in the May number of this journal. Therefore, the terminals of the Crookes tube maintain their identity; that is, one is always anode while the other is always cathode. If a condenser and Tesla coil are employed, the discharge becomes oscillatory and the tube terminals are alternately cathode and anode. For use with an induction coil alone, the middle plate should be made the anode, and the two end plates should be connected together and made the cathode. In this case the cathode rays strike the anode and the Röntgen rays are projected therefrom. With oscillatory discharges, the tube is connected so that the two end terminals are the electrical terminals, the middle plate being disconnected from any source of power. It will be seen that as the end terminals become alternately cathode, they project the cathode rays upon the middle plate and thus generate the Röntgen radiations. In either case it will be noted that all of the cathode rays generated in the tube are projected against the middle plate and are thus effective.

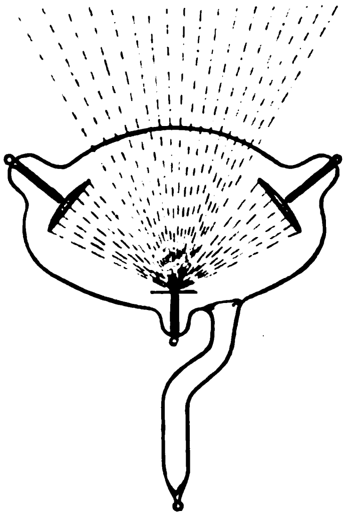


FIG. 3.

Tubes like that shown in Fig. 4 are quite common. Röntgen pictures can be secured with such a tube, but the best results are not attained. On examining the tube with a fluoroscope, it will be noted that the light is not evenly distributed. The edges of the cathode terminal project the cathode rays against the glass directly in line with the plane of the terminal disk. This line of fluorescent glass is the most brilliant source of the Röntgen rays, and is sure to make a white streak across the picture. This non-uniform distribution is, of course, undesirable. Another shape of tube, which is on the market, shown in Fig. 5, is built upon the theory that the Röntgen rays come directly from the cathode. This was one of the first theories and has been discarded. Such a tube will give results perhaps as good as any of the tubes not specially designed for Röntgen pictures, but is not an improvement on them, for the theory on which it was designed has not proven to be the correct one. The tube shown in Fig. 6 has also been used. It will be noted that its distinguishing feature is the auxiliary terminals on its exterior. These enhance the Röntgen effect. They

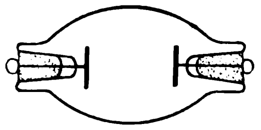


FIG. 4.

are merely a modification of the tubes without terminals passing through glass, and, in fact, are a combination of tubes with external terminals, and tubes with internal terminals. The benefits of this practice may readily be had on any Crookes tube by pasting a tinfoil cap about each terminal, and electrically connecting it therewith. Whatever the benefit of the tinfoil cap as far as Röntgen rays are concerned, it is decidedly useful in preserving the tube, as it minimises the danger of puncturing. The tube shown in Fig. 7 is perhaps the best tube of any of this class, having but two terminals. The saucer shaped terminal is the cathode, and from what has been said its principle will be seen at a glance. It was designed by a professor at King's College, London. It will give good results with an induction coil, but is not suitable for use with disruptive gap currents.

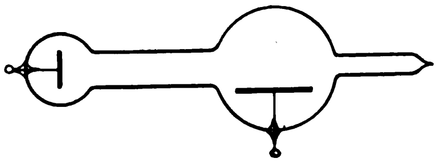


FIG. 5.

The shape of the terminals is also quite important, but aside from arranging them for projecting the cathode rays, little experiment has been made. In Crookes tubes, before Röntgen rays were known, terminals were made of many shapes, but with other purposes in view. Flat and saucer shaped disks are used with success, and there is the specially shaped reflector terminal in the Thomson projector tube already described. The writer has noted that cathode rays are projected with great intensity from sharp points and edges, and suggests that tubes be constructed with cathode terminals armed with sharp points, the better to project the cathode rays against the generating plate. The value of this idea requires to be experimentally demonstrated as yet.

The degree of the vacuum is the next important feature. To every degree of vacuum there is a corresponding electrical excitation which gives the best results. Highest vacua are not necessarily the most desirable. It is said that superior results are obtained where the vacuum is at that degree of alternation that the striæ just disappear.

Continuous excitation of a Crookes tube has the effect of raising the vacuum, but if the excitation be increased proportionally, the Röntgen effect will be improved. If, however, the excitation is at its limit, the tube can be brought back to its range by gently warming it in a Bunsen flame or the flame of an alcohol lamp.

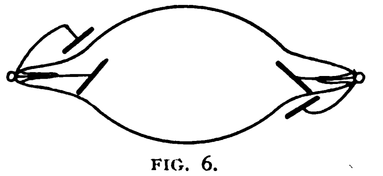


FIG. 6.

The kind of glass of which the tube is made is an important consideration. American glass contains lead, which may be detected from the fact that it fluoresces blue. A suitable glass gives a greenish yellow fluorescence and German glass is said to be superior for this purpose.

In purchasing a Crookes tube it is impossible to tell of its quality by a mere inspection. Reputable dealers in them should provide means for exciting them and a fluoroscope for examination so that the buyer can see exactly what he is getting. The buyer, on the other hand, should insist that the tube be tried in some way before purchasing. At least the tube should be excited so that the grade of glass and the degree of vacuum can be demonstrated.

The Fluoroscope.—The fluoroscope is really one of the most simple parts of a Röntgen outfit. Success is certain to attend the efforts of any one skilled to the slightest degree in the use of tools. It is preferably made of thin wood, but pasteboard also answers excellently. Cigar box wood will be suitable. Suppose the size of the fluorescent screen has been decided to be 6 ins. × 6 ins. The aperture at the eye-end of the fluoroscope should be 4 ins. × 1 in., and the depth of the instrument should be at least nine inches. Anything shorter fatigues the eye in bringing the images to a focus.

Select four pieces of thin wood, ten or more inches in length, and six and one half inches wide. Cut the four pieces, two as shown in Fig. 8, and two others as shown in Fig. 9. Nail and glue them together as indicated in Fig. 10. Round the sharp corners with sand paper and give the end edges a flattening at right angles to the axis of symmetry by means of a sharp plane a sand paper. Glue and nail a suitable handle in place as shown in Fig. 10. Make a mixture of shellac and lamp black, with an excess of the latter, and give two coats of this mixture to the interior of the truncated pyramid. The interior must be light tight.

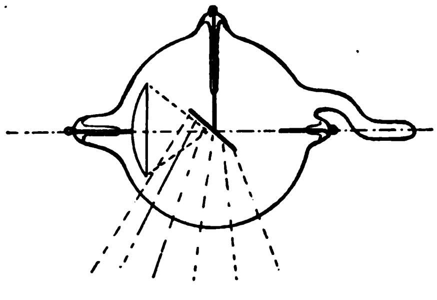


FIG. 7.

Cut a piece of stiff bristol board to fit the large end of the box. This board is now to be prepared to receive the calcium tungstate, which is, probably, the best salt to use for the purpose. Platino-cyanide salts are quite expensive. The board should be thoroughly coated with shellac, and the fluorescent salt sprinkled upon it while it is still sticky. The calcium tungstate should not be powdered, but should be allowed to retain its crystalline form. When complete the prepared screen resembles coarse sand paper in mechanical appearance. It may be secured in its place by light wire nails supplemented with glue. The cracks should now be closed by gluing paper over them in neat strips. It should then be given a coat of shellac and lamp black, the shellac being in excess so as to make the finish glossy.

The principal dimensions of the leather shield for the eyes are given in Fig. 11. In making this it is well to cut the pattern out or dark paper, and fasten it about the fluoroscope and trim it to fit the face as required. The leather may then be cut from this corrected pattern. It should be secured in place about the mouth of the fluoroscope with a gimp tape and brass tacks. A soft fringe trimming should be sewed to the outer edge of the shield. The ends may be shaved and lapped, and the joint secured with belt cement. If well made, the instrument should have a neat, attractive appearance.

Mr. Herbert B. Shallenberger has kindly supplied to us the following information concerning the making of Röntgen radiographs. As stated above, the radiographs made by him have been remarkable for their definition and delicate shading; the latter characteristic, however, unfortunately does not admit of reproduction in half tone cuts, and therefore, does not show in the illustration on another page.

As to the plates which are best, Mr. Shallenberger differs in opinion from some other investigators, since he has found that as between fast and slow plates, those which are rapid for ordinary photography are rapid for Röntgen ray pictures and, as one would naturally expect, in proportion to their sensitometer number. The statement made by Mr. Edison some time since that plates which were slow or suitable for landscape purposes were most rapid for the production of Röntgen pictures, he has never been able to verify; in fact, the results of his own experiments have disproven it. He has found a plate manufactured by the M. A. Seed Dry Plate Company, sensitometer number 26x, to be very excellent for the purpose. These plates are placed in an ordinary plate holder having an ebonite slide, thoroughly light tight. The plate holder, wherever possible, is placed in a horizontal position on a table or other secure support, and the tube placed on an independent stand, as free from all motion as possible.

The distance of the tube from the plate must be determined by the thickness of the object to be photographed, but should always be far enough to cause the shadow to be as little larger than the object as possible. Mr. Shallenberger has found that from twelve to fourteen inches between plate and tube is right for an 8 × 10 plate, and for such parts as the hand, ankle or elbow, is sufficient to give good results. For thicker portions of the body, such as the chest, the distance must be greater—from twenty-four to thirty inches—and the exposure must not

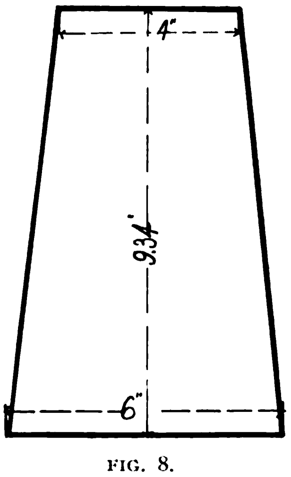
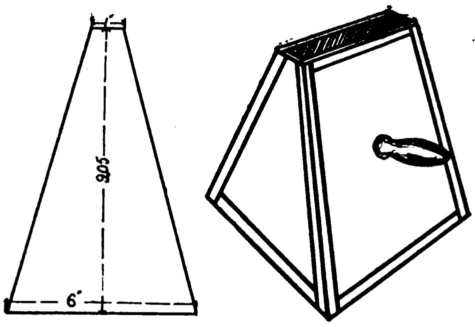


FIG. 8.

only be made longer to suit the greater thickness of the object, but also to suit the distance, as the power of the rays varies inversely as the square of the distance.

He has always tried to so time the exposures as to show the different layers of tissue, and this is best accomplished by somewhat under-exposing the plate and working it very slowly in the developer. This latter point particularly applies to Röntgen ray exposures, as it was very soon discovered that the gelatine film was acted upon throughout its entire thickness, instead of on the surface only, as in ordinary photography. After placing in the tray and flooding with developer, some little time elapses before the image begins to appear, when it develops rather suddenly, and after becoming quite distinct, sinks into the film and acts much like an over-exposed plate. The developer should at this point be slightly weakened, and the plate, screened from the light, should be allowed to remain in it until the light from the red lamp will not penetrate through it, and a strong positive can be distinctly seen by looking at the back of the negative. This produces a plate having fine contrasts and possessing excellent printing qualities. With the ordinary photograph this treatment would produce a very harsh result, but the Röntgen picture seems to require a building up, as it were, of the entire film.



FIGS. 9 AND 10.

A developer composed of equal parts of "Eikonogen" and "Hydroquinone," made according to a formula of his own, has been found by Mr. Shallenberger to be all that could be desired for this work. It admits of a wide range of exposure, is readily controlled, gives a black and white negative, and deals gently with the fingers. Aside from these advantages, it may be used repeatedly if so desired, which, however, is not advisable, as one never knows what to expect from a developer which has been used and allowed to stand. It is well to retain a small amount of the spent developer, as by adding a little of it to the fresh, it prevents too vigorous an action.

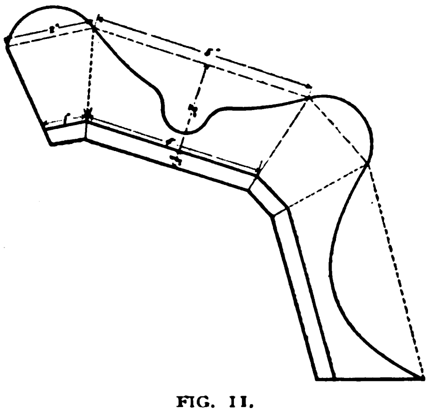


FIG. 11.

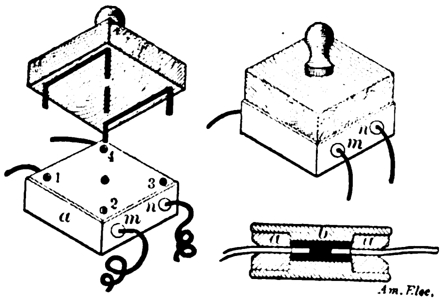
The making of prints from the negatives should be given fully as much attention as the negatives themselves, as otherwise the careful, patient work which has been necessary up to that point, will all have been in vain. Mr. Shallenberger long ago abandoned the old "printing out" process, and now confines himself entirely to a process of development which is so flexible as to admit of almost any treatment of the print. The paper used in connection with this developing process should be a gelatine paper, such as "Solio" or "Albuma."

* * *

ELECTRICAL CONNECTORS.

In experimental electrical apparatus it is well known that the ordinary contacts sometimes introduce a large resistance into the circuit because of oxidation or insufficient pressure. To remedy some of the defects, eliminate time as far as possible in making connections and avoid many of the accidents liable to happen during experiment, the following apparatus has been devised by F. E. Austin, Hanover, N. H.

The reversing switch shown consists of a slate base, *a*, having four holes, 1, 2, 3, 4, containing an amalgam or pure mercury. In the holes, *m*, *n*, which connect with 2 and 3, are inserted two rubber stoppers with a very small hole in their centers. When it is desired to connect the circuit to the switch, all that is necessary is to insert the ends of the copper wires of the line through the minute hole in the stoppers, which will enlarge to a considerable degree, due to the flexibility of the soft rubber, which also causes the hole to close completely when a wire is withdrawn. To reverse, all that is required is to lift the top of the switch by the handle and turn through one quarter revolution. The mercury makes excellent contact while the heavy slate base gives the instrument stability.



ELECTRICAL CONNECTORS.

A connector, also shown herewith, consists of a hard wood or rubber cylinder, *b*, having a central hole filled with conducting amalgam, and the ends fitted with soft rubber stoppers, *a*, *a*, through which the wires of the circuits can be inserted. This connector avoids the possible loss of screws as in ordinary connectors, the loss of time in making connections, and, being made of insulating material, the possibility of a short circuit. It can be seen that the principle of these connectors, which can be made of any form, is readily applicable to a great number of experimental uses.

FAULTS IN DYNAMOS.

Open circuits on an armature betray their nature and locality as quickly as do short circuits. The moment that they occur, the commutator flashes up violently, and on shutting the machine down the bars connected to the bar just in front of the defective bobbin are found to be severely burned. A mere inspection of the armature will disclose the location of the open circuit, as there are usually not more than two, and often only one, layers of wire on machines of any size.

An open circuit in the field is perhaps the most difficult of all faults to locate. It often occurs on the outside of the field magnet itself, and the writer has known of cases where the trouble was sought for in the field magnet when it consisted of a burned out coil in a rheostat, or even was simply a case of leaving the field switch open. Sometimes the break will occur at the terminals, the wire being broken off close to the body of the coil. It is very likely to be in the outer layer, as that part of the coil is liable to damage.

Cheaply made, high voltage, shunt field coils are very liable to open or short circuit, as they are wound without regard to layers or turns, and in such coils, unfortunately, the trouble is exceptionally difficult to locate. This cheap and unreliable construction is used considerably, even by firms of established reputation. If an open circuit occurs while the machine is in operation, and in the interior of the field magnet, it is always serious. A flaming arc follows the break and often burns a hole in the body of the field coil as large as a hickory nut.

Open circuits are most readily detected with a magneto bell, and may be approximately located by connecting the magneto to the inner end of the field coil, and the free terminal to a cambric needle; the latter can be thrust gently into the coil from the outside, and will soon strike a turn through which the magneto rings, showing that the break lies in the layers already pierced by the needle. This method should not be tried with either very fine or very coarse windings, and the needle should be annealed so that it will bend before it will break.

While it is obvious that electrical faults are confined to failure of either the copper conductors or the insulation surrounding them, yet they occur in such a variety of ways and produce so many different effects that a review of a number of actual cases within the writer's experience may be instructive.

A most puzzling special case was that of a short-circuited bobbin of a sixty-light Brush dynamo. Contrary to the general rule, this bobbin did not betray its condition by burning out or even overheating, for the great number of turns and the almost complete iron circuit surrounding them, gave the coil such a high self-inductance that it effectually choked down the current that otherwise would have been generated. For a long time the fault baffled detection, and the only indication of its existence consisted in the fact that the machine fell sixteen per cent. short of its normal voltage. It was finally discovered by measuring the resistance of the coils successively. As there were only six sets, this labor was not great. The exceptionally low resistance of the faulty coil, of course, betrayed it.

Another case where the difficulty was equally elusive occurred on an electro-plating machine. The machine, which was of the Brush series type, refused to generate, and, of course, an open circuit was at once suspected. The machine was tested with a magneto, and its circuits were found to be apparently intact. After a long, tiresome search the fault was found. One of the rocker cables was not clamped tightly enough to its connector, the fault being an open circuit. This case is a good illustration of how readily a magneto test may lead one astray, Here was a good circuit for the magneto with its relatively high voltage, but one through which the machine with its extremely low voltage failed to force sufficient current to start the excitation. This kind of trouble, however, is not confined to low voltage machines; it may occur on machines having a voltage of two or three thousand volts. Whatever the running voltage of a machine, the conditions may be such that the starting voltage is the merest fraction of a volt, and a fault of the nature just described can prevent such a machine from building just as easily as if the running voltage were very low. Where this trouble is suspected, the magneto should be discarded, and the tests made with a single dry battery and an ordinary electric bell. The magneto will ring briskly through a circuit where the bell and battery will fail.

An interesting case was that of a short circuited Brush arc armature. Connection was made between the armature terminals through the iron rocker arms, the fault being a double arc. For some reason it was suspected that the armature—a new one—was not properly connected, and in investigating this point the brushes were taken off. The fault, of course, disappeared as soon as the short circuited portions were thus isolated, and the armature tested out properly. On replacing it the trouble reappeared and defied detection until it was noticed that there was a circuit through the machine with two of the brushes off. An examination of the faulty rocker arm disclosed the difficulty.

In a bipolar, constant potential machine, a curious fault once developed in the writer's experience. The commutator and armature ran very hot, even when the load was completely off and the machine was generating current barely sufficient to excite its fields. The writer used a magneto to test the machine while it was being assembled, and each segment of the commutator and coil of the armature was found impervious to the electromotive force of the magneto, which could readily ring through 10,000 ohms. It was discovered that the shellac was of a poor quality, and on being heated it became conducting. It had been liberally applied to the interior of the commutator when it was assembled, and when all of the bars were connected together by the winding, their combined area of imperfect contact was sufficient to pass considerable current, which heated the commutator and windings. The fault was removed by baking out the commutator for a long period of time. This remedy would not always be successful, but the impurities in the shellac were, in this case, of such a nature that the treatment thoroughly cured the difficulty.

Electrical faults are very nearly covered by the class of troubles involving either copper or insulations, and comprise short and open circuits and also grounds. There are, however, a number of mechanical faults that are liable to occur in dynamos, and their detection is often fully as difficult. Several of these that are often puzzling are worthy of mention.

There are quite a number of smooth cored drum machines now in use, that have their core punchings insulated from the shaft. These machines are always very old, for the practice of so insulating core disks has been proven to be superfluous. Such a machine, after years of running, will pulverize the insulation next the shaft, and presently the disks will have sufficient play to throw the armature out of balance. If the offending member be taken out and rebalanced, it will immediately throw itself out of balance again and be as bad, if not worse, than ever. Presently the disks will be so loose that they will shift on the slightest provocation, and balancing becomes an impossibility. Then the armature must be removed and stripped and the core rebuilt. In rebuilding such a core, it is much better to use cast iron sleeves rather than wooden bushings, as with the iron sleeves the same trouble can never occur again. Another trouble which is quite frequent in occurrence, especially with new machines, is the shifting of the commutator bars. A commuator that has been running smoothly will suddenly begin to cut on one side of every bar, and will feel to the fingers as though it were a ratchet wheel. The fact often is, that the bars have, as a whole, taken up a new position, and their radial center lines are now at an angle with their former position. Sometimes a commutator will do this a number of times before it finally decides to stay fixed, the operation being very analagous to the settling of the foundation of a building. The only method is to tighten the retaining rings, and turn down the commutator after every shift of position.

A sprung shaft and a shaft out of line will both cause hot bearings, and it is difficult for some people to detect the difference. A shaft out of line turns hard in its bearings uniformly throughout a revolution. A sprung shaft, on the other hand, has periods of free and confined motion during a revolution. Realignment will correct the first difficulty, but it will be a skillful job for a good machinist to correct the second. If a machine has self-aligning bearings, it may be run even though the shaft is sprung, by loosening the caps of the bearings; but loosening the caps of such bearings, will not cure heating that is due to any other cause. Running a machine with a sprung shaft, whatever method is used, is, however, only a temporary makeshift.

The faults that can occur on a dynamo electric machine are comparatively few in number, but they disguise themselves under so many different modifications, and by simultaneous occurrence, that they often puzzle the expert. The only way to acquire ability to successfully cope with them is to never be satisfied with a cure simply, but to search diligently after the cause.

THE INDICATOR CARD.

In order to determine the horse power being exerted by a steam engine, it has been shown that what is required to be known is the distance through which the engine piston travels in a minute and the average pressure behind the piston.

In regard to the first point—the travel—it will readily be seen that the fact of the piston having a to-and-fro motion introduces no complication, since the pressure is exerted and work done exactly as if the travel were continuously in the same direction. If, therefore, the revolutions are, say, 114 per minute and the stroke 36 ins. or 3 ft., the piston in one minute, since it makes $114 \times 2 = 228$ strokes in that time, will travel $3 \times 228 = 684$ ft. It must be borne in mind that since horse power refers to *foot*-pounds, the stroke must always be expressed in *feet*.

Next, as to the average pressure. It is evident that as we wish to know the total work of the engine, this quantity must be the average *total* pressure on the piston; since that pressure is always measured in pounds per *square inch*, it will therefore be the area of the piston in square inches, multiplied by the *average* cylinder pressure of the steam per square inch, this latter being determined from an indicator card. Assuming the diameter of the piston to be 28 ins., its total area in square inches will be the square of 28 into the number .7854 or $784 \times .7854$; or, neglecting the fraction, 625 sq. ins., which quantity would ordinarily be taken from a table of areas of circles.

Since, however, on the crank side of the engine the area of the piston on which pressure is exerted is less than on the other side, by the area of the piston rod, allowance must be made for this. If the piston rod is two inches in diameter its area is, in even numbers, three square inches, and the effective area on that side of the piston is thereby reduced to 622 sq. ins. As we never want to know the horse power of each side of the cylinder separately, but merely wish to find the average total horse power, we use in horse power calculations the average of the areas on each side, which in this case is $625 + 622$ or 624 sq. ins., nearly. If now we know the average steam pressure in the cylinder we shall have all the quantities necessary to calculate the horse power. This brings us again to the indicator card.

Fig. 1 is a reproduction of an indicator card taken from an actual engine with a 28 in. × 36 in. cylinder, making 114 r. p. m. The diagram from one side of the cylinder is in full line, and that from the other side is in dotted line, except where the exhaust lines of the two cards coincide. The card was taken with a sixty pound spring, or, in other words, a spiral spring, which, if a pressure of sixty pounds per square inch were admitted beneath the indicator piston, would cause the indicator pencil to move through one inch; the indicator piston itself, however, would move only through one-quarter or one-fifth of that distance, the piston travel being multiplied by the link motion used.

It is evident that if we draw a vertical line at any point of the card, the length of that line cut off by the card will represent the pressure that existed in the steam cylinder at the corresponding point of the engine stroke when the card was taken. If the length of this line measures, for example, 1¼ ins., then the actual pressure at that point was, for a sixty pound spring, 1¼ × 60 = 75 lbs. per square inch. It is also evident that if we were to draw a large number of such vertical lines evenly spaced, the average length of these lines would correspond to the average pressure.

In practice, it is usually necessary to draw only ten such evenly spaced vertical lines. Now it will be seen that if we were to divide the atmospheric line (which represents the true length of the indicator card) into ten parts, and commence the vertical lines at the end, the two extreme lines would measure no pressure at the exhaust ends of the diagrams, and perhaps little or none at the steam ends, only touching these at perhaps a single point. Therefore, it is necessary to commence the vertical lines a *half division* away from the end of the card, as shown in Fig. 1. In practice, if the atmospheric line is divided into ten equal parts, one can make dots midway between the divisions and draw the pressure lines upward from these dots.

Having drawn the verticals or pressure lines, the next operation is to measure the lengths cut off from these by the steam and exhaust lines of the indicator diagrams. Indicators are usually supplied with scales graduated in pounds to accord to the indicator spring used, in which case the lengths measured are read off directly in pounds. In Fig. 1 these measurements are given, the upper ones corresponding to the left hand card, and the lower ones to the right hand card. Adding these together it will be found that the total for the former is 614, or dividing by ten we get 61.4 lbs. as the average pressure for that side of the cylinder; similarly, we find 59.5 lbs. to be the average for the other side of the cylinder. Adding these two averages together and dividing by two, we have, finally, 60.4 lbs. as the average pressure to be used in calculating our horse power.

Since the average area of the piston is 624 sq. ins., and the average pressure of the steam moving the piston is 60.4 lbs. per square inch, the total moving pressure is 624 × 60.4 = 37,689.6 lbs. Since in one minute we have found the piston to move through 684 ft., the foot pounds of work per minute consequently are 37,689.6 × 684 or 25,779,686 ft. lbs. Finally dividing by 33,000, the number of foot pounds per minute corresponding to a horse power, we have $\frac{25,779,686}{33,000} = 781$, which is the horse power of a 28 in. × 36 in. engine at 114 r. p. m. under an average or mean cylinder pressure of 60.4 lbs. per square inch.

In practice it is not customary to measure each pressure length of the vertical lines separately, but to add their lengths on a long slip of paper; that is, by taking a long slip of paper and marking on it the length of the first line by two dots, then moving the second dot to the foot of the next vertical and marking its length by another dot, until the ten lines of one diagram (or even the twenty lines of the two diagrams) are thus added together. Then, by measuring the entire length between the extreme dots on the slip and dividing them by ten (or by twenty if both diagrams are included) the mean or average pressure is at once obtained.

If the card (Fig. 1) were measured in this manner, the length would be found $9\frac{15}{16}$ ins. for the right hand card and 10¼ ins. for the left hand one. As each inch corresponds to sixty pounds of pressure, $9\frac{15}{16}$ ins. would correspond to $60 \times 9\frac{15}{16} = 595$ lbs., and 10¼ ins. to 614 lbs. Dividing by ten we have 59.5 lbs. and 61.4 lbs., as before. As the card has been somewhat distorted in engraving, it might be of interest to some readers to make the necessary measurements and find what horse power the card represents as printed.

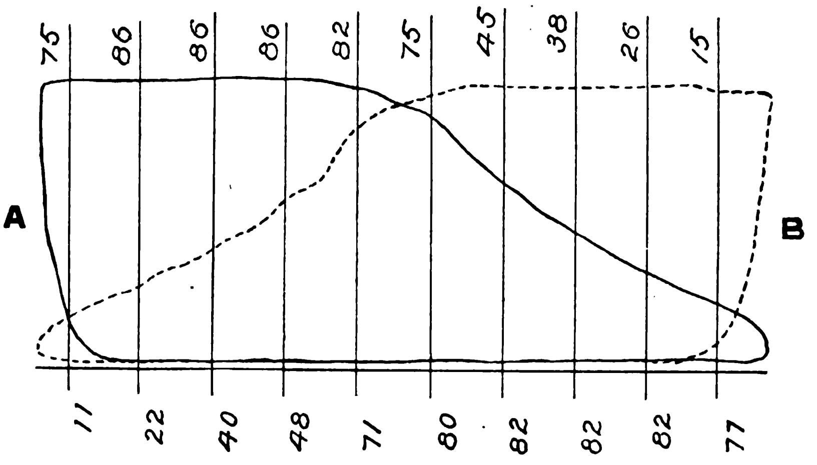


FIG. 1.

We have seen that the horse power is the product of the revolutions, twice the stroke, the piston area and the mean cylinder pressure—divided by 33,000; or, horse power =

$$\frac{\text{revolutions} \times 2 \times \text{stroke} \times \text{area} \times \text{pressure}}{33,000} \qquad (1)$$

Using only the initials, and dropping the multiplication signs, (1) may be represented by the easily remembered expression

$$\frac{2\,R\,A\,S\,P}{33,000}. \qquad (2)$$

Engine constant. Since in a given engine the stroke and the area remain constant, formula (2) may be separated into two parts, one of which, $\frac{2\,A\,S}{33,000}$, is always the same, and the other, R P, varies with the load. It is evident that useless work is done when for each card from an engine we calculate the value of $\frac{2\,A\,S}{33,000}$, and in practice this is never done, its value being found once for all and called the *engine constant.* Having the engine constant, the horse power expression (1) becomes

constant × revolutions × pressure,

and (2) becomes C R P, where C is the value of the constant.

Since the engine constant is twice the piston area in square inches, multiplied by the stroke in feet—divided by 33,000, then in the case of the engine corresponding to the card of Fig. 1, we have,

$$\text{engine constant} = \frac{2 \times 624 \times 3}{33,000} = .113,$$

or roughly, ⅑. In practice the horse power in the above case would have been found by merely multiplying together the revolutions, the mean pressure, pounds and the constant, .113 or horse power = 113 × 60.4 × 114 = 781, as before.

In the next issue the subject of the form of indicator cards will be taken up.

INTERIOR WIRING.

THE CALCULATION OF WIRE.

Although this part of planning a wiring installation is usually performed after the circuits have been designed, yet it is necessary to understand how to calculate the wire in order to use good judgment in laying out the work. It is, in fact, the key note to the whole art of wiring, and, therefore, this matter will be taken up in considerable detail.

By the aid of the table already given, the resistance of any piece of copper wire may be calculated if its length and its gauge be known. Conversely, the length and resistance being known, it is easy to determine the corresponding gauge. The length of the wire is always to be obtained by measurement or consultation of the architect's plans, and the resistance by a consideration of the service the wire is to perform and the results that it is desirable to obtain. Only arithmetic is necessary. The data are always easy to obtain.

In order to calculate the resistance of a wire to be used for a certain service, the volts lost in the line and the current flowing must be known. As before intimated, the line loss is a predetermined amount, and the magnitude thereof is a matter of judgment, instructions or convention. The choice of a line loss in a wire should be based on the losses in the other parts of the system feeding the wire and the parts of the system the wire is to feed, for the whole must not exceed a certain amount—the total volt line loss of the installation. In buildings that are well wired this line loss rarely exceeds five per cent. and is seldom smaller than one per cent. The dynamo is usually adjusted to regulate to this amount.

The current flowing is always calculated by summing up the currents of the various devices that the wire feeds, be they lamps, motors or heaters. In this connection, the following table will be useful:

55-volt systems are almost without exception alternate current systems, and to such currents a special discussion will be accorded. 55-volt motors are mostly fan motors, and take one to two amperes. The 220-volt or three-wire system is also a special case and requires separate treatment.

As far as motors themselves are concerned, the potential that they require is not necessary to their well being, but a variation in terminal potential varies the speed of the motor in almost exactly the same ratio. Constant speed is usually desirable, and, therefore, the rule for wiring lamps should be followed, particularly if lamps are to be fed from the same circuit.

110 VOLT SYSTEM.		
DEVICE.	CURRENT CONSUMED.	
16 C. P. lamp,	.45 to .60 amperes,	
32 " "	.90 "	
50 " "	1.36 "	
100 " "	2.73 "	
Motors, ½ to 2 H.P.	9.6 "	per H. P.
" 2 to 10 "	7.6 "	" "
The last two figures are only approximate.		
55 VOLT SYSTEM.		
16 C. P. lamp.	.90 to 1.1 amperes.	
32 " "	1.8 "	
50 " "	2.7 "	
100 " "	5.45 "	

Incandescent lamp service, on the other hand, suffers seriously if the lamps are not fed at the pressure for which they are rated. If the latter is a few per cent too low, the candle power of the lamp is greatly impaired, while if the error is on the other side, the life of the lamp is greatly shortened. Therefore, considerable care should be used in calculating the wire.

Arc lamps for incandescent circuits, whether they run two in series or singly, always have a dead resistance in series with them that absorbs a certain percentage of the line voltage. If such lamps are used on circuits that are exclusively their own, copper may be saved by feeding them with the smallest wire that the insurance companies will permit. By cutting out a portion of the dead resistance in the interior of the lamp, the reduced voltage at the terminals may be compensated for. If, however, the the same wire feeds incandescent lamps also, this little economy cannot be practiced.

As has been mentioned before, there are two methods of calculating wire in common use. The one gives the resistance of the wire in ohms, and the other gives its area in circular mils. The first is more convenient in interior wiring. It involves no new principles, is easily understood and the calculations involved are very short. It can only be conveniently used when a wire table giving the resistance of standard wires per unit of length is to be had. American practice is such that the average contractor will find it very inconvenient to use any wires other than those of the B. & S. gauge, and, in fact, many contractors use only the even numbers of this gauge above No. 6, as the odd numbers are not largely kept in stock.

The problem, therefore, is, which of the standard wires that the contractor may be compelled to use will be the most suitable?

The method giving the circular mils is, of course, more definite, as it gives the actual size of the wire rather than one of its electrical properties. It is useful in all cases where the wire has to be specially made, as is often the case with large street feeders. It will, therefore, be given a place in this discussion, but as the resistance method is to be preferred for interior wiring, more stress will be laid upon it. In general, the resistance method is as follows: Having determined the current flowing and fixed upon the line loss that it is desirable to have, it is obvious that dividing the line loss by the current gives the resistance of the wire, for such is Ohm's law. Dividing this result by the length of the proposed wire in feet, the resistance in ohms per foot is evidently attained. As resistance tables usually are for lengths of 1000 ft., this latter quantity should be multiplied by 1000 in order that the proper gauge number may be determined by a mere glance at the table.

Mathematically the result may be expressed as follows:

$$R_f = \frac{E}{CL}$$

where E represents the line loss, C the current and L the length of the wire in feet; R_f, of course, represents the desired resistance per foot of the wire. This method is sufficient to solve any problem in direct current, constant potential, house wiring.

The above rule is susceptible of a convenient modification, as follows: A convenient term in house wiring is known as "lamp feet," which quantity is obtained in any case of a wire feeding a group of lamps or a network of wires, by multiplying the number of lamps by the distance in feet that the current is to be transmitted along the wire in question. Each lamp is supposed to be a sixteen candle power lamp. For example, if it were required to transmit current to a twenty-light chandelier from a pair of mains 100 ft. away, the circuit would be said to involve 100 × 20 or 2000 lamp feet. The distance, it will be noted, is the single distance and not the distance to the chandelier and return. The current consumed by an incandescent lamp varies according to its make, its rated efficiency and its period of service. As has been noted, this current in a 110-volt lamp is from .45 to .60 amperes, and in 55 volt lamps of the same candle power, from .90 to 1.1 amperes. In any group of lamps it is probable that in time all sorts of current values will be represented between the limits, and therefore an average is the only rational figure to take in making the calculation for the wires. Fortunately, for purposes of calculation this average, in the case of the 110 and 55-volt systems, is .5 and 1 ampere respectively This fact makes the calculations notably simple. Referring to the formula,

$$R_f = \frac{E}{CL},$$

it will be seen that if we multiply the number of lamps by the current that one takes, we shall have the total current, C. If the number of lamps be represented by N, then .5 N equals C in the case of 110-volt lamps, and can be substituted therefor in the formula. Also, L equals twice the distance from the point of supply to the lamps, for it represents the length of the wire, and there are two wires between these points. If F equals the single distance, then L equals $2F$ and this can also be substituted in the formula, which will then read,

$$R_f = \frac{E}{.5N2F} \text{ or } \frac{E}{NF}$$

Now NF is equal to the number of lamps multiplied by the distance in feet, or the lamp feet. The rule then becomes: Divide the line loss by the lamp feet and the result will be the resistance in ohms per foot of the proper wire. For 55-volt systems, the current is practically double, and twice the lamp feet should be used as the dividing factor.

Taking a problem, suppose that in a large hall there is a fifty-light chandelier which is to be fed from a switch cabinet 150 ft. away, the system being 110 volts. The line loss is not to exceed one volt. The lamp feet are 50 × 150 = 7500, and the resistance of the proper wire is $\frac{1}{7500}$ of an ohm per foot which, decimally expressed, is .000133 ohm. The nearest B & S size, it will be seen by consulting a table, is No. 1. This rule is readily remembered and simple, and is effective except in a few special cases where its application is awkward, but of these more hereafter.

The second method, which gives the circular mils of the wire, is embodied in the following formula:

$$A = \frac{LCR}{E},$$

where A equals the area in circular mils, L the length of wire (double distance), E the line loss and R the resistance of one mil-foot of copper wire—that is, the resistance of a copper wire one foot long and one one-thousandth of an inch in diameter. For ordinary copper wire this figure is about 10.8, a rather inconvenient constant. When using this method, unless the wire is to be specially drawn, reference must be had to a wire table to determine the most suitable size to use. Illustrating this method by the same problem as before, we have

$$A = \frac{300 \times 25 \times 10.8}{1} \text{ or } 81{,}000 \text{ c. m.},$$

corresponding most nearly to No. 1 B & S gauge, as before.

It will be seen at once that one more factor is involved in the calculation, and the formula requires to be memorized. Moreover, a wire table is just as necessary as with the first method, provided standard sizes are to be used, as is generally the case.

The use of the slide rule is much to be recommended in calculating wire. It saves considerable mental exertion, and after a little practice in its manipulation no mistakes are made. Its accuracy for all small wires is amply sufficient. A good operator can always obtain three places of figures, and standard wires do not come nearer than this. Three figures, be they ohms or circular mils, will locate the proper wire in its table to the exclusion of all others. The application of both of these methods to actual problems in interior wiring may be a little difficult to the novice, but numerous problems will be given and worked out, thus rendering their application a simple matter in subsequent work. The student can now appreciate one of the first principles of circuit design, which will be developed in a following issue.

EFFICIENCY OF THE ELECTRIC LIGHT.

According to Palaz, the light-efficiency of the incandescent lamp is three to five per cent, and of the arc light, about fifteen per cent.

REPAIR OF ELECTRIC RAILWAY APPARATUS.

BY W. E. SHEPARD.

WESTINGHOUSE CONTROLLER.

While the General Electric Company has sent out a considerable number of different styles of motors, it has made but few changes in the type of controller. The Westinghouse Company has, on the other hand, changed frequently its controller, while adhering very closely to the original form of motor.

The earlier forms of Westinghouse controllers are known by the several alphabetical letters down as far as type G. Controllers B, C, D and E are much in use and were put out with the earlier motors, which were arranged for parallel running with rheostat control. Type G was first adopted for series-parallel running, but was soon superseded by type 14. This latter was followed by 28 A, which is the controller now being sent out.

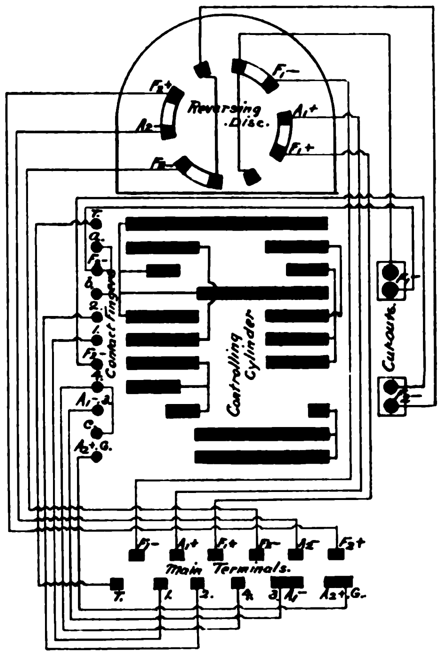


FIG. I.—PLAN OF WIRING.

The most commonly used at the present time, with series parallel motors, is the 14. This controller is shown closed in Fig. 2. In Fig. 3, the cover is removed and the contact cylinder is thrown back. The eleven contact fingers are shown at the left of the cut, the twelve main cable terminals near the bottom, and the two cut-out plugs near the center. The reversing switch is in the form of a flat disk of slate or porcelain, and is located immediately underneath the heavy brass top of the controller, which, owing to the shadow, is hardly discernable in the cut.

The controlling cylinder is supported by hinged brackets and is so arranged that by releasing two heavy thumb-nuts and withdrawing the upper portion of the stem of the cylinder, it can be swung back, as shown in the cut, thus exposing the contact fingers and allowing free inspection and repairs of the cylinder.

A plan of the wiring of the controller is shown in Fig. 1.

With this controller there are six speed points. The first two have resistance in series with both motors in series. At the third point both motors are in series with all resistance cut out. At the fourth and fifth the motors are in parallel, each having resistance in their circuit, and at the sixth notch the motors in parallel with all resistance cut out.

We will trace the current through its course when running on the first point in series, and also for the first point in parallel.

First, when running on first point—series at notch No. 1. The current comes in from the trolley and flows to main terminal T; to to contact finger T; to contact 2: to main terminal 2; through first half of rheostat back to main terminal 1; to contact 1; to contact a; to contact F_1—; to F_1— on cut-out; to F_1 — on reverse; to main terminal F_1—; through field No. 1 back to main terminal $F_1 +$; to $F_1 +$ on reverse; to $A_1 +$ on reverse; to main terminal $A_1 +$ through armature No. 1 back to main terminal A— and 3; through second half of rheostat back to 4; to contact F_2 — to F_2 — on cut-out; to F_2 — on reverse; to main terminal F_2—; through No. 2 field back to main terminal $F_2 +$; to $F_2 +$ on reverse; to A_2— on reverse; to main terminal A_2—; through No. 2 armature back to main terminal $A_2 +$ and to ground.

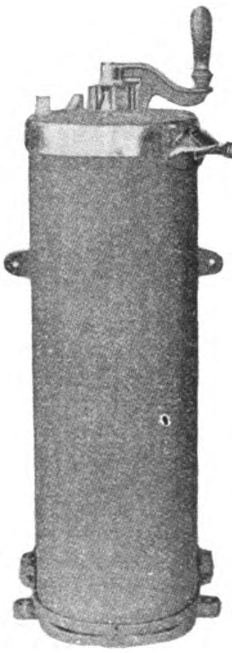


FIG. 2.—WESTINGHOUSE CONTROLLER, TYPE 14.

Second, when running on first point in parallel, notch No. 4.

Current coming in from trolley flows to main terminal T; then to contact T; to contact b; to contacts F_1— and a; here the current divides, part flowing from contact F_1— to cut-out F_1—; to F_1 — on reverse; to main terminal F_1—; through field No. 1 back to main terminal $F_1 +$; to $F_1 +$ on reverse; to $A_1 +$ on reverse; to main terminal $A_1 +$; through No. 1 armature back to main terminal A_1—and 3; through first half of rheostat back to main terminal 4; to contact 4; to contact c; to contact $A_2 +$ and ground. The other part of the current from contact b flows to main terminal 2; through second half of rheostat back to main terminal 1; to contact 1; to contact a; to contact F_2—; to F_2 — on cut-out; to F_2 — on reverse; to main terminal F_2 —. through No. 2 field back to main terminal $F_2 +$; to $F_2 +$ on reverse; to A_2 — on reverse; to main terminal A_2 — through No. 2 armature back to main terminal $A_2 +$ and to ground.

It may be of interest here to compare the different relative arrangements of armature, field and rheostat as adopted by the several companies, and we will tabulate those arrangements for comparison, first when running on the first series point, that is notch No. 2, and second, when running on first notch in multiple. The current in each case enters from the trolley and flows through the several parts, in the order named, to the ground.

First Notch in Series.	First Notch in Parallel.	
	WALKER.	
Trolley. Armature No. 1. Field No. 1. Rheostat. Armature No. 2. Field No. 2. Ground.	Trolley. Rheostat.	
	Armature No. 1. Field No. 1.	Armature No. 2. Field No. 2.
	Ground.	
	GENERAL ELECTRIC.	
Trolley. Rheostat. Armature No. 1. Field No. 1. Armature No. 2. Field No. 2. Ground.	Trolley. Rheostat.	
	Armature No. 1. Field No. 1.	Armature No. 2. Field No. 2.
	Ground.	
	WESTINGHOUSE.	
Trolley. ½ Rheostat. Field No. 1. Armature No. 1. ½ Rheostat. Field No. 2. Armature No. 2. Ground.	Trolley.	
	Field No. 1. Armature No. 1. ½ Rheostat.	½ Rheostat. Field No. 2. Armature No. 2.
	Ground.	

From the fact that the potential of the current at the trolley is, say, five hundred volts, and that it gradually becomes less throughout the circuit, until, at the ground, it becomes *nil*, it is usually customary to place those parts of the apparatus which can be most highly insulated and are cheapest to repair, in the position of highest pressure, that is, nearest the trolley. The rheostat is usually selected for this place. At first it would appear that this would be a very important requirement, but when we consider that on the most important notches, the last ones, when the heaviest currents are passing, the rheostats are cut out of the circuit and only armatures and fields left, the objec-

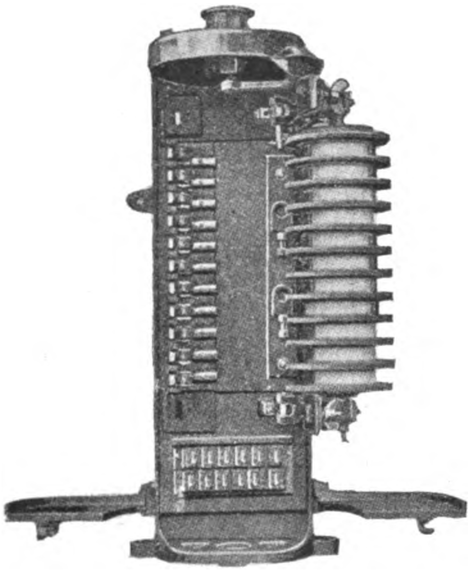


FIG. 3.—WESTINGHOUSE CONTROLLER, TYPE 14.

tions to varying the relative position of the rheostat do not seem so great.

However, to consider the remaining parts, the fields and armatures. Both the Walker and the General Electric Companies place the field coils nearest the ground, the armatures nearest the trolley, while, on the other hand, the Westinghouse Company reverses this order and puts the armature nearest the ground with the field coil nearest the trolley. This latter arrangement results in less strain being put upon the armatures, with a correspondingly less tendency to grounding, and, also, when ground *does* occur, a somewhat less fierce arcing and burning with its consequent changes to the armature. On the other hand, the field coil is called upon to withstand a greater pressure, and, when it breaks down, is subject to greater damage. The field coil is, however, a comparatively simple coil of wire, easily repaired and capable of very thorough insulation, and it would seem that the arrangement adopted by the Westinghouse Company, *per se*, would result in the less damage and less expense for repairs.

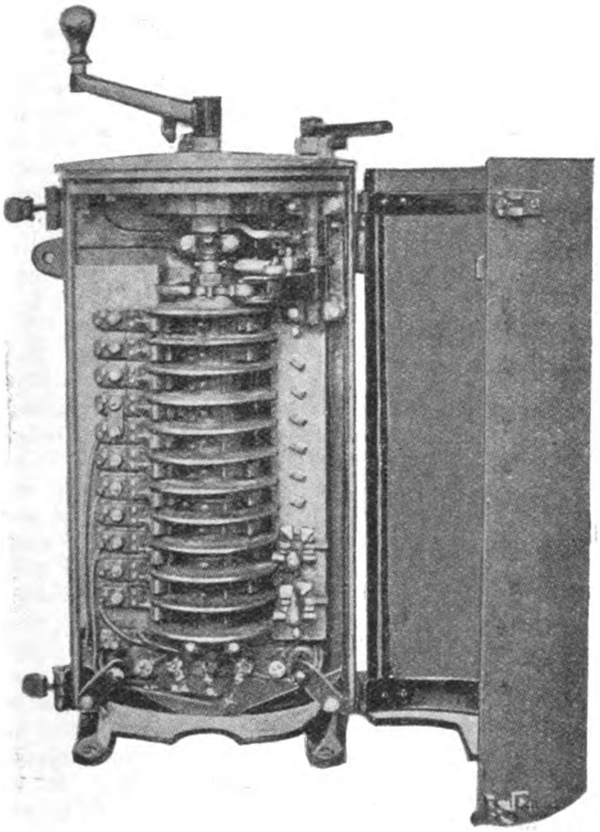


FIG. 4.—WESTINGHOUSE CONTROLLER, TYPE 28A.

What has already been said in regard to care of the contacts of the type K 2 controller of the General Electric Company is true of this controller. The copper contact rings should be very slightly lubricated with vaseline or tallow, and should be dressed up from time to time, the worn out fingers and tips removed and replaced by new ones.

With the type 14 and some of the preceding types, porcelain has been used to fill out the segments between the ends of the cylinder rings. Constant sparking at the tips rapidly cracks and chips this away, as it is unable to withstand the intense fire from the arc. The writer has found the substitution of so called "lava," in place of these porcelain pieces very desirable. This material is manufactured by the M. D. Steward Manufacturing Company, of Chattanooga, Tenn., and is little, if any more expensive than the porcelain. The material is brittle, like porcelain, but is very hard, so hard it cannot be drilled or tooled at all, but it is able to stand the ordinary sparking of a controller almost indefinitely.

The controller which at present is being sent out by the Westinghouse Company, known as the 28A, is quite similar to the type 14, differing from it only in detail of mechanical construction. This controller, with cover thrown back, is shown in Fig. 4.

As will be noticed, the reversing gear is the same, except that the handle is arranged on the top of controller instead of at the side, as in type 14. The cylinder is composed of several iron castings, each having lugs extending outward, for the purpose of supporting the copper segments in their several proper positions, thus doing away entirely with the porcelain segments used in type 14. The cylinder is not arranged to swing open, but may be readily taken out, and the main cable terminals are distributed around at the sides and bottom of the controller. The cut-outs also are slightly different in form.

With the type 14 controller, when motor No. 1 is cut out, motor No. 2 will not start until the controller handle is thrown over to the fourth point, when, in order to operate the car, notches Nos. 4, 5 and 6 are used. When motor No. 2 is cut out the car is operated on notches Nos. 1, 2 and 3.

With type 28A, no matter which motor is cut out of circuit, the remaining motor is operated on notches Nos. 1, 2 and 3, the controller handle being locked from passing beyond this point.

◆

A TOWN ELECTRIC LIGHTING PLANT WANTED.

In a communication to the AMERICAN ELECTRICIAN, Hon Henry L. Hart, mayor of Louisiana, Mo., states that the present contract for lighting the streets of Louisiana, Mo. (a city of about 6000 people one hundred miles north of St. Louis on the Mississippi River) will expire about Oct. 1, at which time or before the City Council will probably make arrangements for a plant operated under city control, make a contract with the present company, or accept bid from some other party.

◆

AN 80,000-AMPERE METER.

In the article on the National Electrical Exhibition which appeared in our May number, the capacity of the Weston ampere meter illustrated was erroneously stated to be 180,000 instead of 80,000 amperes, this latter figure, in fact, being marked upon the gauge as illustrated.

LESSONS IN PRACTICAL ELECTRICITY

OHM'S LAW AND GENERAL CONSIDERATIONS.

It is an obvious truth that the greater the force applied, whatever that force may be, the greater the effect; and, conversely, the greater the resistance offered to a force, whatever form that resistance may take, the less the effect. This general law of nature has, most happily, an extremely simple expression in electrical science, and full benefit of this simplicity has been taken by the adoption of a rationally devised system of units. The form which the law assumes with respect to electricity was first definitely established by a German savant, Dr. G. S. Ohm, in 1827, and has since borne his name.

Ohm's law may be expressed in three different forms, according to whether the quantity to be defined is current, electromotive force or resistance. The most familiar form, though perhaps not the most useful practically, refers to current, and is as follows, in terms of practical electrical units and with respect to continuous currents:

The current, in amperes, flowing in a closed electrical circuit, is equal to the electro-motive force of that circuit, in volts, divided by the resistance, in ohms.

This may be simply expressed as follows:

$$\text{Current in amperes} = \frac{\text{Electromotive force (in volts)}}{\text{Resistance (in ohms).}}$$

In applying the above expression it is, of course, unnecessary to write out the names in full; using, therefore, merely the initial letters we have, finally,

$$C = \frac{E}{R} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; (1)$$

The above, it should be added, is merely one of the simple forms of Ohm's law, and with respect to continuous currents; as will be seen later, it takes on a different expression with respect to alternating currents, but, nevertheless, the general law remains unchanged. The electromotive force (abbreviated E. M. F.), or the E in the formula, refers to the *free* E. M. F. That is, if in a circuit we had three cells, each of one volt E. M. F., and all arranged to act in the same direction, E would be three volts; if, on the other hand, two cells were arranged to act in one direction and the third in an opposite direction—the latter backing against the other two—E would be $2 - 1 = 1$ volt.

The other two forms of Ohm's law are,

$$R = \frac{E}{C} \quad . \; . \; . \; . \; (2) \qquad E = CR \quad . \; . \; . \; (3)$$

Why the law should necessarily take three forms will be plain to the student of algebra; to others, slight thought will show that any one of three related quantities can be expressed in terms of the other two. To illustrate, suppose in an electrical circuit in which five amperes are flowing, there is an E. M. F. of ten volts, and that the entire resistance of the circuit is two ohms. Then we have,

$$C = \frac{E}{R} = \frac{10}{2} = 5;$$

$$R = \frac{E}{C} = \frac{10}{5} = 2;$$

$$E = CR = 5 \times 2 = 10$$

from which it will be seen that the three formulas are merely expressions of the same law with respect to each of the three different quantities involved. Each of the three formulas has its specific use, depending upon the conditions.

As a numerical application, we will suppose that it is required to know the resistance necessary to put in series with a ten-ampere, fifty-volt arc lamp in order to run it on a 110 volt circuit.

In order that 10 amperes shall flow through a circuit connected to 110 volt mains, there must be in that circuit a resistance (or its equivalent), of a value obtained by substituting the values of E and C in the formula $R=\frac{E}{C}$, or $R=\frac{110}{10}=11$ ohms.

Since 10 amperes flow through the lamp when there are 50 volts between its binding posts, the equivalent resistance of the lamp, obtained from the same formula, is $\frac{50}{10}=5$ ohms. Therefore, it will be necessary to put $11-5=6$ ohms in circuit with the lamp, in order that but 10 amperes shall flow through it.

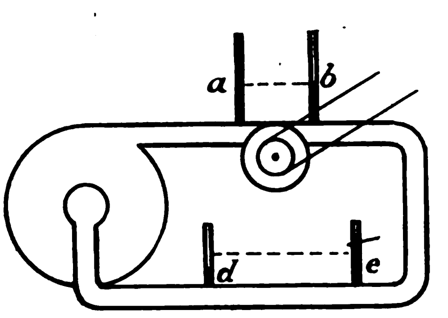


FIG. 1.

Another way of looking at the same problem is to consider that the resistance must be of such a value as to produce a *drop* of $110-50=60$ volts in the lamp circuit. The formula, $E=CR$, which may be called the "drop" formula, can here be used; substituting in it, we have $60=10\times R$ or $R=$ 6 ohms. Formula (2) might also be used, but (3) was chosen on account of the idea of drop associated with it.

The most important application of formula (2), $R=\frac{E}{C}$, is for the calculation of wiring. Here E represents the drop due to the current, C, and the resistance, R, of the wire through which the current passes. Drops are usually expressed in percentages; in incandescent wiring, for example, they range from one to five per cent., or from 1.1 to 5.5 volts, on a 110 volt circuit. As an example of the calculation, suppose a feeder for 100 110-volt lamps is required to run from a dynamo to, say, a distributing center 100 ft. from the generator, the drop to two per cent. What size of wire will be required? The drop in volts will be 2.2, and if each lamp takes one-half ampere, the current will be 50 amperes. From the above formula, we find the resistance to be $R=\frac{E}{C}=\frac{2.2}{50}=$ .044 ohm. As there are two legs, 200 ft. of wire will be required, and if the resistance of 200 ft. is .044 ohm, the resistance of 1000 ft. will be $5\times .044=.22$ ohm. Referring to a wiring table, in which resistances are usually given for lengths of 1000 ft., we find that .22 ohm corresponds to 1000 ft. of wire of a size near that of No. 3 B & S.

The total voltage existing in a primary or secondary cell, or being generated in a dynamo does not show at the binding posts when a current is flowing, owing to the drop due to the resistance of the cell itself. Suppose we take the case of a dynamo generating 120 volts, as an illustration. Though 120 volts are being generated in the armature wires, perhaps only 110 volts at ordinary load will show at the binding posts, for the reason that there is a drop of ten volts in the armature and field, due to their resistance and the current passing.

The total E. M. F. being generated can not be measured when the dynamo is delivering current, but may be calculated by means of the drop formula above. Supposing the dynamo to be a series machine, by substituting in the formula, $E=CR$, the current and the sum of the resistance of the field winding and the resistance of the armature winding from brush to brush, the drop will be obtained; this added to the E. M. F. at the binding posts gives the total E. M. F. generated. Taking a 50-light, 2500-volt, 10-ampere arc machine as an example, the resistance of the field and armature may be 25 ohms; consequently, since ten amperes are flowing, the drop will be $10\times 25=250$ volts, and the machine will actually be generating 2750 volts, though but 2500 appear at the binding posts.

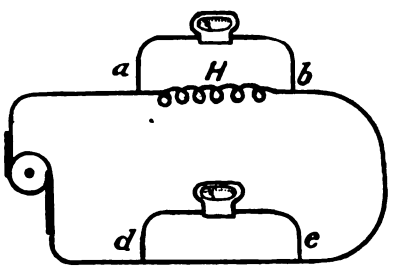


FIG. 2.

In order to make the bearing of the several formulas perfectly clear, it will be well to consider the relations between the several electrical properties of an electrical circuit. We will here only take up the case of continuous current circuits containing no motors.

In considering dynamo or battery circuits, confusion may be avoided by thoroughly distinguishing between the functions of the E. M. F. and current. The force which causes the current to flow resides in the cell or in the armature, and, therefore, it is desirable to think of electromotive force in connection with the *generator*. On the other hand, that which produces an effect at a receiving apparatus is the current, consequently it is desirable to associate the thought of current with *receiving* apparatus.

Fig. 1, represents a centrifugal pump hydraulic circuit, in which the pressure forcing the water around the circuit is generated, of course, at the blades of the pump. Suppose there is a water motor, A, in circuit and that on each side of the motor is a water column, a, b. Then the column, a, will register the pressure generated in the pump (if there is atmospheric pressure at the axis of the pump), less the pressure lost by friction between the column and the pump blades, and its height may be called the *potential* at the point where it enters the pipe. The column, b, will register the pressure on the other side of the pump, and its height may similarly be called the potential at the point where it enters the pipe. The height of the column, b, however, will be less than that of a by an amount equal to the pressure to overcome the resistance offered by the motor. This difference in height (or difference of potential) is, therefore, a drop in E. M. F. due to the resistance encountered by the flowing water. In the same manner, the friction of the pipe itself will cause a drop, as shown at d and c.

Referring to Fig. 2, a voltmeter connected at a and b will show the drop due, say, to an electric heater, H, and another voltmeter at d and c will show the drop due to the resistance of the circuit wire itself between these two points. The points a and b and c and d may be considered to be at certain potentials, as in the hydraulic analogue, the difference between these potentials constituting the drop in E. M. F.

From the foregoing, it will be seen that the E. M. F. generated in a cell or machine is dissipated in overcoming resistances, and that between the extremities of any resistance, a certain amount of E. M. F. is dropped corresponding to the value of the resistance and the current flowing, as expressed in the formula, $E=CR$. In most cases it will be well to think of this drop only in connection with the current producing it, instead of referring the E. M. F. at a receiver back to its origin at the dynamo. The drop results from the flow of the current, and in a given resistance is larger or smaller as the current is greater or less; as current is usually taken from mains proceeding from machines over whose E. M. F. the user has no control, there is an additional reason for considerating current primarily.

To produce any desired result in a receiving apparatus, a definite amount of current effect is required. In electroplating, for example, a certain amount of current per square inch is needed; with incandescent lamps, a certain amount of current is required for normal incandescence depending upon the size and character of the carbon filament; in magnetic apparatus, such as dynamo fields, a certain amount of current flow is needed, which may either be a large current flowing through few turns or a small current flowing through many turns.

The amount of current effect is thus fixed for a given purpose, while the E. M. F. at the receiver terminals may vary widely, being dependent upon the practical conditions. In electroplating, for example, articles may be placed in series, thus requiring a larger E. M. F., but the current per square inch of material must remain the same; in an incandescent lamp, the amount of current per unit of area of filament is practically unchanged for normal conditions, but long, fine filaments will require more E. M. F. per inch of length than short, stout ones; a magnet of given strength requires a definite current effect, or ampere twins, which may, according to the practical conditions, be produced by a very large or a very small E. M. F.

A BIOGRAPHICAL HISTORY OF ELECTRICITY.

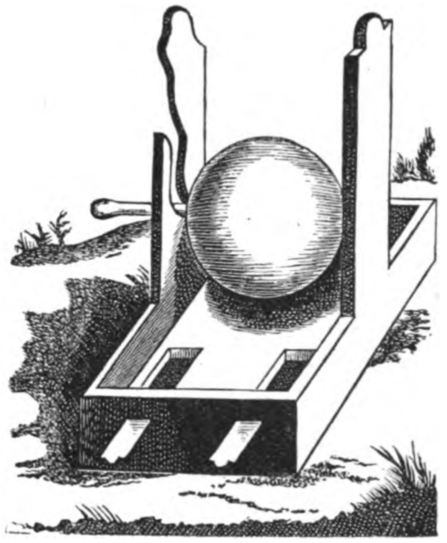
Between Gilbert and Franklin there are recorded in electrical history four great names—Otto Von Guericke of Germany, Francis Hauksbee and Stephen Gray, of England, and Charles Francois Dufay, of France. With Gilbert, the first of these forms a link between the metaphysical, and the modern school of physical investigators as represented in its beginning by the latter three.

Otto Von Guericke was born at Magdeburg, Saxony, Nov. 20, 1602. In 1627 he was elected alderman of Magdeburg, and in 1646 mayor and magistrate of Brandenburg. While holding these offices he devoted much of his time to scientific investigation and philosophy, and in 1650 invented the air pump, with which his name is most closely connected.

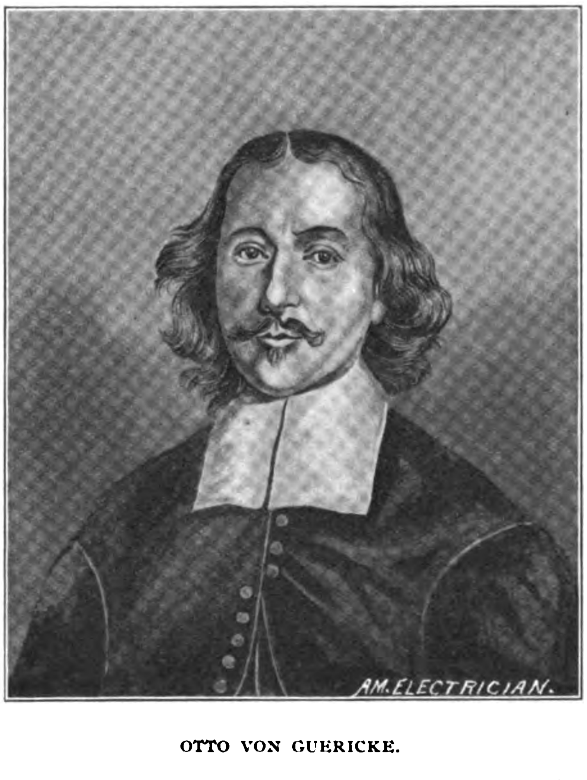
Von Guericke made the first electrical machine, which is shown in an accompanying illustration, consisting of a sulphur ball turned by a crank on an axis and excited by the friction of the hand. Crude though this apparatus may be, yet it was by its means that the electric light, feeble indeed, was first produced, or first recognized. The original object of the globe was to more conveniently excite the sulphur as an electric in order to extend the experiments of which Von Guericke had read. By its means he first definitely established the principle of electrical repulsion, and also observed, but did not establish, the principle of electrification by induction.

The electrical discovery, however, with which his name will be always most closely identified, is that of producing light from electricity. He relates that "upon drawing a large piece of amber swiftly through a woolen cloth and squeezing it pretty hard with my hand, a prodigious number of little cracklings were heard and every one of these produced a little flash of light; but when the amber was drawn gently and slightly through the cloth, it produced only a light, but no crackling; but by holding one's finger at a little distance from the amber, a large crackling is produced with a great flash of light succeeding it. And what to me is very surprising, upon the eruption it strikes the finger very sensibly, wheresoever applied with a push or a puff like wind. The crackling is full as loud as charcoal on fire, and five or six cracklings or more, according to the quickness of placing the finger, have been produced from one single friction, light always succeeding each of them. This light and crackling seem in some degree to represent thunder and lightning." This appears to have been the first time that the identity of electricity and lightning was asserted.

Picard (1675) and Bernouilli (1700) having discovered that the vibration of the mercury column of a vacuum tube caused a light to appear in the vacuum space, Francis Hauksbee, about 1705, took up the study of this phenomenon, and produced the first vacuum light. Sir Isaac Newton had previously used glass in place of amber, sulphur, etc., in electrical experiments, which material was adopted by Hauksbee in his investigations. He constructed an electrical machine consisting of an exhausted glass globe or cylinder with hemispherical ends, which were mounted in bearings so as to revolve axially. He observed that upon applying his hand to the surface of the tube when it was turned, a strong light appeared in the interior of the tube. He also discovered that by approaching an unexcited vacuum tube to one in which light was being produced by friction, the first tube would be illuminated similarly to the excited one. The light produced by Hauksbee was, "so great that large print without much difficulty could be read by it, and at the same time the room, which was large and wide, became sensibly enlightened, and the wall was visible at the remotest distance, which was at least ten feet."



THE FIRST ELECTRICAL MACHINE.


AM. ELECTRICIAN.

OTTO VON GUERICKE.

During Hauksbee's experiments he observed a singular phenomenon which recently one of our English contemporaries has advanced as an anticipation of Röntgen's great discovery. One of the cylinders having had the cylindrical portion of its interior coated with sealing wax to a thickness in places of ⅛ in., Hauksbee noticed, when looking through the uncoated ends, that when the cylinder was revolved the outline of his hand was distinguishable through the coating of wax; the same result was obtained when pitch and sulphur were used as the coating material. Hauksbee was much mystified at this phenomenon and Priestly, writing in 1769, refers to the experiments as "really amazing" and as not having "been yet pursued in the manner they deserved."

Dufay, however, in a note to the French translation of Hauksbee's book in which these experiments are described, points out that the hand and fingers were merely outlined by electric sparks from the interior surface of the wax, and gives an account of experiments whereby he proved this.

The discoveries of Stephen Gray, a pensioner of Charter House, may be said to have placed electrical science on a real foundation. In attempting to account for some unusual electrical phenomena, he was led to experiment upon the effect of an electrified body on a neutral body when both were connected by string. He began by hanging a loop of pack thread from a beam and securing an ivory ball on one point of it and a glass tube at another, there being thus, in effect, a horizontal line suspended by two vertical lines of the same material. No result was obtained from this arrangement, but at the suggestion of a friend, Wheeler, he substituted silk suspensions and found that upon rubbing the glass tube the ivory ball became electrified. Gray interpreted this experiment as showing that the pack thread permitted electricity to pass while the silk interrupted its passage, or, in other words, he discovered the properties of electrical conduction and insulation. He then proceeded to experiment with other bodies which he classified according to the above properties. Gray and his associate, Wheeler, were much gratified when they finally transmitted the electric current through as much as 725 ft. of pack thread supported by loops of silk, and (in August, 1730) through 866 ft. of wire. Gray also noticed the phenomenon of static induction, but made little headway in its investigation.

Dufay, who took up Gray's work and immensely extended it, had been educated as a soldier, but all his tastes were inclined toward science, in several branches of which he became the most proficient savant of his time. He discovered that all bodies, solid and liquid, could be electrified, by first placing them on glass stands, thus doing away with the former classification of electrics and non-electrics. Repeating Gray's experiments, he found that moisture assisted the passage of current in pack thread, and that substances most easily electrified by friction were the worst conductors, and *vice versa*. He also first used the terms, "conductors" and "non-conductors."

Dufay's later work, on account of its connection with that of Franklin, will be considered in an article on the latter.

ELECTRICAL CATECHISM

10. How is a shunt dynamo started?

If the machine has been running before and everything is in good order, simply let down the brushes so that they press against the commutator, and bring the machine up to speed. If everything is all right, the field magnetism will "pick up" as the machine comes up to speed, and in a short time the machine will be generating full voltage. The voltage may be adjusted up or down by moving the rheostat handle.

11. How does the shunt of a field dynamo pick up?

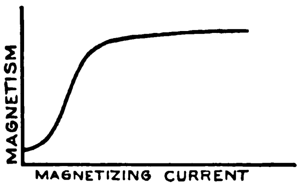
After a machine is stopped, the iron of the field magnet retains more or less magnetism, being in fact a semi-permanent magnet. This residual magnetism furnishes a weak field which causes a small electromotive force to be induced in the wires on the armature as the machine comes up to speed. If the armature and field coils form part of a closed circuit, the small E. M. F. induced by the residual magnetism sends a small current through the circuit. This current strengthens the magnetic field and causes a still higher E. M. F. to be induced. This again sends still more current through the field coils, and the machine thus quickly builds up its magnetism and voltage to full strength.

12. What prevents the voltage of a shunt dynamo from increasing indefinitely?

The machine is so designed that the iron of the field magnet becomes more or less saturated by the time the voltage has risen to the desired amount.

13. What is meant by the saturation of iron?

This may be explained by the accompanying figure in which the curved line represents the relation between the magnetizing current and the resulting magnetization. After the iron has been magnetized once it retains a certain amount, as indicated by the curve, beginning at some distance above zero. For small magnetizing forces the permeability of the iron is small, and the magnetization increases slowly. The permeability then increases and the magnetization increases rapidly until the iron approaches the saturation limit. The upper sharp bend in the curve is called the saturation point, since after the iron has been magnetized up to this point, it is difficult to magnetize it much more strongly.



14. How can one tell the normal speed of a dynamo?

Usually the speed is stamped on the name plate on the machine or on the end of the armature shaft. Belt driven machines usually have a velocity of 3000 ft. per minute as measured around the outside of the armature, although some machines run at 4000 ft. or more. Machines directly coupled to engines sometimes run as slowly as 1600 ft. per minute.

15. How can one tell the normal voltage of a shunt dynamo?

A shunt dynamo usually has quite a wide range of voltages at which it will operate successfully. It is common to have a machine able to generate about fifty per cent above normal voltage when the main switch is open so that the machine delivers no current except for its own fields, when the resistance is all cut out of the shunt field rheostat and when the machine is running at full speed. It is now customary to make shunt dynamos for 125, 250 and 600 volts.

16. How can one tell the full load current of a shunt dynamo?

If this is not marked upon the name plate or armature shaft, one can tell either by running the machine for one or two hours, or by finding the size of the wire on the armature. Modern dynamos are so designed that the temperature of the armature will not rise more than 75 degs. F. above the temperature of the room when delivering full amount of current. Older machines were rated higher and would reach a higher temperature.

17. How can one determine the temperature of an armature?

Have a thermometer that reads as high as 212 degs. F. or 100 degs. centigrade, preferably a straight one without a wooden or tin case and with the scale marked on the glass tube. Immediately after the machine has stopped running lay the thermometer upon the armature in such a position that the bulb rests directly upon the armature wires or on the iron core. Cover the thermometer carefully with waste or something similar, so as to hold the bulb in position and also to prevent any currents of air from cooling it. In a few minutes the thermometer will indicate the temperature of the armature. The difference between this and the reading of a similar thermometer hung in the air a few feet from the machine gives the rise of temperature of the armature.

18. Is it true that an armature is cooler while running than after it stops?

It is true with armatures that are not thoroughly ventilated, because while running the armature creates a current of air like a fan that carries off the heat from the surface, so that the surface is cooler than the inside of the armature. When the armature stops, the current of air also stops, and the whole of the armature comes to about the same temperature. Therefore the surface becomes warmer for some time after the armature stops running.

19. How can one tell the allowable current from the size of the armature wire?

Determining the size of wire and the total number of circuits among which the armature current is divided. Determining also whether each path consists of a single wire or of two or more wound as one. From a wire table, find the number of "circular mils" in the wire used, multiply by the total number of wires in parallel, and divide by 600. The result is about the number of amperes the armature can probably deliver without excessive heating.

QUERIES AND ANSWERS

Is porcelain better than mica for insulation in suitable places? I have found that even the best mica when subjected to high voltages becomes perforated. F. D. W.

Porcelain has a specific resistance more than fifty times greater than mica, and five times greater than ordinary glass, according to Mascart. Whether this applies to commercial porcelain and mica or not, the former, where suitable, is preferable for the reason that it will naturally be thicker.

How is the lifting power of alternating current magnets calculated, and how many layers deep can the coils of such a magnet be wound without introducing the choking effect? F. D. W.

A magnet with a laminated core only moderately magnetized will have the same pull with an alternating as with a continuous current of the same strength. The formulas for calculating the lifting power of constant current magnets can, therefore, be ordinarily used for alternating magnets. A peculiarity of alternating current magnets is that they give a fairly constant pull over a long range if supplied from a constant potential circuit. A choking effect will always be present, but can be decreased without decreasing the power of a magnet, by using a less number of turns and increasing the current. In the present state of the art, it is better to design alternating current magnets experimentally than to attempt their calculation.

Why is it essential to have a magnet always double? W.

In order to have as complete a magnetic circuit as possible and, therefore, of greatest strength, a magnet is so shaped that both its poles may be opposite an armature or keeper, which latter completes the magnetic circuit when it touches the poles. It is to accommodate the magnetizing coil to this essential shape that such coil is usually divided into two parts. A magnet with two coils is, therefore, not a double magnet.

If in an alternating circuit with transformers, there are resistance coils in the primary circuit, would there be greater current flow in the primary circuit, and would there be higher E. M. F., induced in the secondary circuit, if these resistance coils were cut out? C. T.

With a given impressed E. M. F. the suppresion of the resistance must increase the current flow. Whether the increase will amount to much will depend on the original relations between resistance and inductance. It does not appear that it makes any difference whether the resistance is concentrated or distributed over the inductive circuit. In either case, when the resistance is suppressed more current must flow so as to increase the inductive E. M. F. until it alone becomes equal to the impressed. Of course, the increased current of the primary must give rise to an increased E. M. F. in the secondary.

Why do copper brushes cut more than carbon brushes? S. B. F.

Two reasons may be given: First, if carbon brushes spark at all, the spark is much less vicious, on account of their higher resistance as compared with copper. When a brush is in contact with two commutator bars, a local circuit is formed, consisting of the armature coil between them and the brush surface; if this surface is of low resistance, like that of copper, a strong current flows through the local circuit, which causes a considerable spark when it is broken by one of the bars passing from under the brush. Second, a sparking copper brush cuts the commutator and aggravates the sparking with every revolution, whereas a carbon brush lubricates the commutator and tends to minimize the cutting effect of the sparks.

1. Are high speed, closed coil machines more apt to spark with change of load than low speed ones? 2. Does increasing speed of a given machine cause sparking? S. F. B.

1. Much depends upon the design. Abstractly considered, the speed has no effect upon the sparking, provided the machine runs at the rate specified by the designer. Given a high speed and low speed machine built according to the same design, the probability is that the low speed one will spark more than the other because of the greater armature reaction due to larger number of conductors. 2. Yes, if the voltage remains fixed, because if the speed is carried above the normal point the field must be weakened to avoid excessive voltage. If the speed is increased in order to obtain higher E. M. F., the tendency to sparking will be reduced, because the higher voltage at the terminals of the shunt field coils results in a stronger magnetic field while the armature reaction remains unchanged.

How can a 500 volt armature be changed to one of 250 volts by merely reconnecting, it being wound with two No. 7 B. & S. wires in parallel? F. W.

Move the top wires in each commutator bar one bar further away from the bar containing the other end of the coil, and bridge the bars between the coils. Referring to Fig. 1., move the two top ends from *A* to the preceding bar; those in *B* go into *A*, those in *C* go into *B*, those in *D* go into *C*, and so on around. Then bridge across from *A* to *B*, from *C* to *D*, from *E* to *F*, and so on. The commutator *must* have an *even* number of segments in order to do this. The field coils must be connected in parallel instead of series, if there are two; if more than two (Fig. 2.), divide into two groups, the coils of each group being placed in *series* and the two groups in parallel.

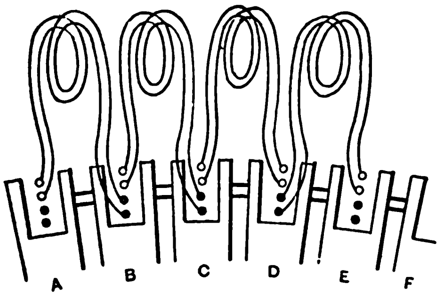


FIG. 1.

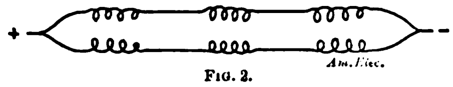


FIG. 2.

Does the number of amperes in the primary of an induction coil have anything to do with the voltage at the secondary? W. D. S.

The voltage of the secondary depends upon the ampere-turns of the primary—that is, the amperes multiplied by the number of turns of wire in the primary. In a given coil, therefore, the voltage of the secondary necessarily depends upon the amperes in the primary.

Which is the more correct term to use, Röntgen ray or X ray? A. N. W.

The former, for several reasons. By scientific etiquette the name of the discoverer should be used to distinguish a new phenomenon in the absence of a direct qualifying word. We thus have Peltier effect, Hall phenomenon, Hertzian waves, Leonard rays, etc. The term "X-ray" was doubtless used by Professor Röntgen with the expectation that scientific courtesy would replace the symbol X with his own name. The term X-ray has been discredited by its exclusive use by the horde of cranks and notoriety seekers brought forward by Röntgen's discovery, many of whom, no doubt, were attracted by the very singularity of that term.

We have a small Mordey alternator and have been trying to rectify part of its current after leaving a transformer by means of a sewing machine motor with a shuttle armature, but thus far have been unable to get the latter up to speed. Will this arrangement work? KIMBERLY.

The speed of the motor would, probably, be too great, even if it could be gotten into synchronism. Why not put the rectifying commutator on the alternator shaft?

1. How many batteries does it take to run a small fan motor, and what type of cell should be used? 2. What is the difference between battery and dynamo motors? J. R.

1. Find the voltage for which the motor is wound, and divide by the working voltage of the type of cell to be used; this will give the number of cells, which should be of the constant current type. 2. The difference lies in the windings, the former being wound for low E. M. F. and the latter usually for 110 volts.

What is meant by "Tree" and "Closet" systems. of house wiring? S. B. F.

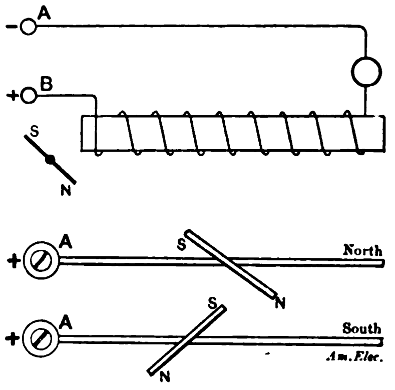
In the former system all lights are fed from single sub-mains and branches leading from this at intervals to groups of lamps. The main or feeder may be compared to the trunk of a tree and the sub-mains and branches to the limbs and branches of a tree. The "Closet" system is one in which feeders supply two or more distributing centers, from which radiate the lines carrying lamps, and is much the preferable system. The name of the latter system is derived from the location of the distribution centers.

Suppose current sent through an electric motor as usual, but the armature does not magnetize, would the armature turn? J. O'H.

An iron core would always magnetize; if it did not, it would be the equivalent of, say, a wooden core, and the break in the magnetic circuit, instead of being the length of the two gaps between the core and bore, would thus be the entire distance from the surface of the bore on one side to the surface on the other, and consequently but few lines of force would be forced across to act upon the lines from the armature wires whereby motion is given. The armature core of a dynamo or motor may, in one sense, merely be considered as part of the magnetic circuit, the clearance between the field magnet bore and armature core in this case, on account of containing the lines of force from which current or motion is obtained, being the only "working" portion of the magnetic circuit. With a wooden core, enough field lines might be forced across to give slow motion at no load, but with an ordinary drum or Gramme core, no load could be carried.

How can the positive pole of a dynamo be distinguished? L. T.

1. About a piece of soft iron take a number of turns, *clockwise*, of a lead from one of the binding posts of the dynamo. Then, if the end of the iron *toward* the dynamo repels the south pole of a magnetic needle, the binding post from which the lead proceeds is positive (Fig. 1). If an incandescent dynamo, one of the leads of an incandescent lamp connected across the poles may be used. A magnetic needle may be made by placing a piece of darning needle or steel wire across the pole gap of the dynamo; the length of the piece should be but little greater than the width of the gap. 2 By means of a thread secured by wax or otherwise to the middle ot a magnetic needle, such as the above, suspend the needle horizontally over, and close to, any lead of the dynamo carrying considerable current which runs approximately north and south. With the back toward the part of the lead that is connected to the dynamo, the north pole of the needle will be seen to be deflected to the right (Fig. 2), if the lead connects to the positive pole of the dynamo. 3. In a glass containing water acidulated with sulphuric acid (ten parts water, one part acid), place two pieces of clean lead and connect the same to the two poles of the dynamo, putting an incandescent lamp in series (Fig. 3). The surface of the piece of lead connected to the positive pole will become reddish brown after taking current for some time, and the surface of the other piece will assume a grayish color. This method may be applied to incandescent and storage battery charging dynamos, but not, of course, to arc machines.



FIGS. 1 AND 2.

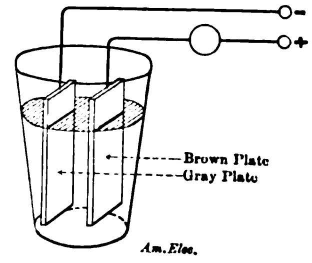


FIG. 3.

Do the lines of force in a multipolar dynamo go from one pole to the pole next to it, or across the armature to the opposite pole? W. D. S.

The lines of force coming from a pole divide, half the lines going to the pole next to it on one side and the other half to the pole on the other side.

New Apparatus and Appliances.

THE VINDEX TRANSFORMER.

In the article in the May issue of the AMERICAN ELECTRICIAN, describing the Vindex transformer, it was erroneously stated that the transformer was made by R. Ralph Lane & Company, Monadnock Block, Chicago, Ill. The makers of the transformer are the Vindex Electric Company, Chicago, Ill., Mr. Lane being the selling agent.

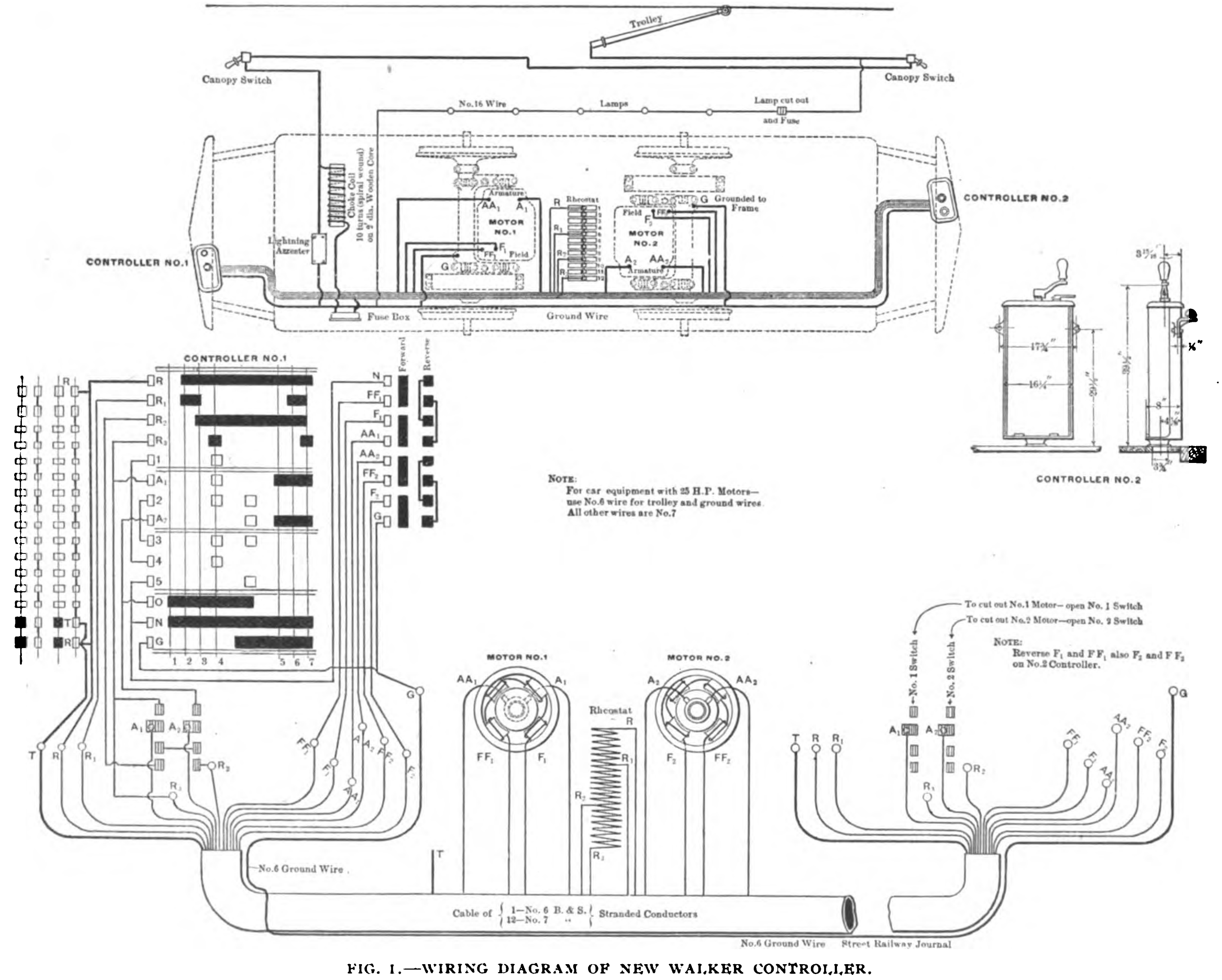
THE NEW WALKER MULTIPLE-SERIES CONTROLLER.

The Walker Company, of Cleveland, O., has recently brought out a new series-multiple street car controller, which is shown in the accompanying Figs. 1 and 2. Fig. 3 is a wiring diagram of the connections between the car motors and the controller.

In this controller the circuit is broken by a special switch placed in the controller for the purpose, in which the action is relatively slow, and the circuit is broken at twenty-eight points, thus very easily rendering the most severe arc that can be formed in practice entirely harmless, both as to spreading to other contacts and as to its effect on burning the breaking contacts themselves.

Another feature consists in entirely separating the operation of breaking the circuit from the controlling cylinder itself. The controller consists of two switches, each having its own separate function to perform. The controlling cylinder proper is used simply to make the different combinations required to obtain the proper regulation of the speed of the car. The second switch is also of a cylindrical form, but is used for no other purpose than the complete breaking of the circuit whenever such is required. By reference to the cut it will be seen that the breaking switch, which is shown at the left, has its circuit so arranged that the main current passes first through this switch, before going to the controlling cylinder. In the four lines of contacts shown, the first and third constitute the cylindrical portion of the switch, and are in metallic connection each with the one horizontally opposite to it. The second and fourth rows represent the fingers bearing upon the cylinder contacts. It will be seen by tracing out these connections, that when the switch is closed the upper contacts, shown in outline, are short circuited, the current simply passing from top to bottom and then direct to the controlling cylinder. As this switch is opened the fingers leave the lower contacts, shown solid, first throwing the main current through the upper breaking contacts in the series, so that when the fingers leave the cylinder contacts the arc is broken up into as many parts as there are breaking fingers.

The mechanism of the breaking switch is so arranged that with a movement of the controlling handle one quarter of an inch backward, the circuit is completely opened by means of this switch, leaving the controlling cylinder itself entirely dead. The circuit cannot be again closed until the controlling handle has been brought back to the off position. After the circuit has been once opened by this slight backward movement of the handle, the controlling cylinder can be moved backward and forward into any position without producing any effect, and it is absolutely necessary to go back to the off position before the switch can again be closed. This feature of the controller makes it impossible to drop back from one notch to another in such a way as to put in or take out resistances in the circuit. This is a point that has always heretofore been carefully covered in the instructions to motormen, but at the same time it has been found that such instructions are often disregarded, it being much easier in many cases, if a decreased speed is wanted, to drop back one or two notches, as the case may be, instead of first cutting off the current completely.



NOTE:
For car equipment with 25 H.P. Motors—use No.6 wire for trolley and ground wires. All other wires are No.7

To cut out No.1 Motor—open No. 1 Switch
To cut out No.2 Motor—open No. 2 Switch

NOTE:
Reverse F_1 and FF_1 also F_2 and FF_2 on No.2 Controller.

Street Railway Journal

FIG. 1.—WIRING DIAGRAM OF NEW WALKER CONTROLLER.

Another point of considerable advantage is the quickness with which the circuit can be opened in case of an emergency. A very silght movement of the handle entirely cuts off the current from the car, thus leaving the motorman free to attend to his brake promptly, with both hands if necessary.

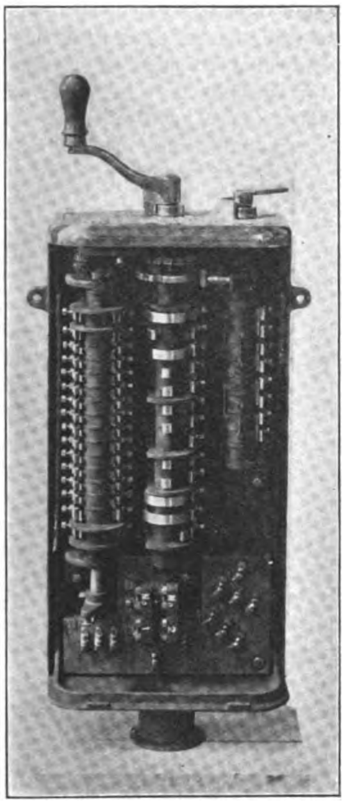
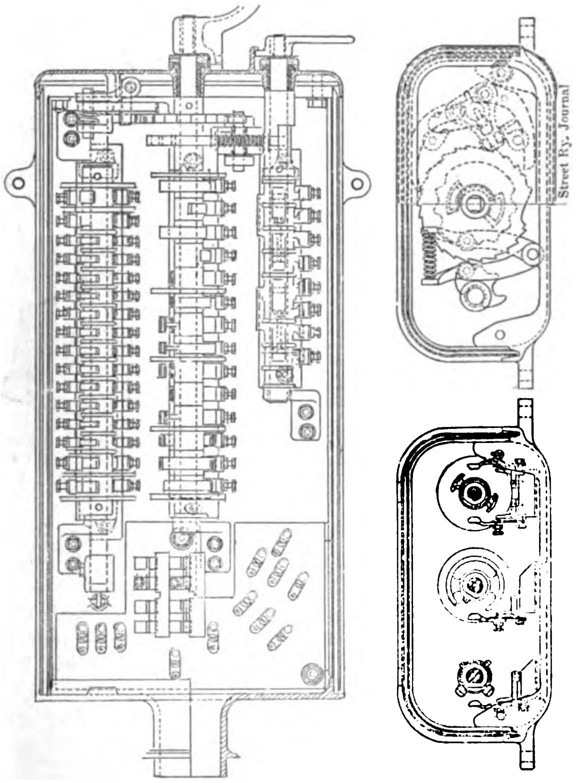


FIG. 3.—NEW WALKER CONTROLLER.

A simple and effective interlocking device has been adopted in this controller, whereby the pawl that indicates the various running positions of the controlling cylinder acts at the same time as a lock between the controlling cylinder and the reversing switch. The controlling cylinder is locked when the reversing switch is in any other position than either forward or back, and the reversing switch is locked except when the controlling cylinder is at "off" position.



Street Ry. Journal

FIG. 2.—DETAILS OF NEW WALKER CONTROLLER.

The internal wiring of the controller has also been much simplified and, as will be seen from the cut, the wiring is entirely open so that it can be easily seen and gotten at. With this method of breaking the circuit, it has been found that separators between the various contacts are entirely unnecessary and consequently have been done away with. The arcing in this controller under the severest conditions of practice is stated to be so slight that it is scarcely noticeable.

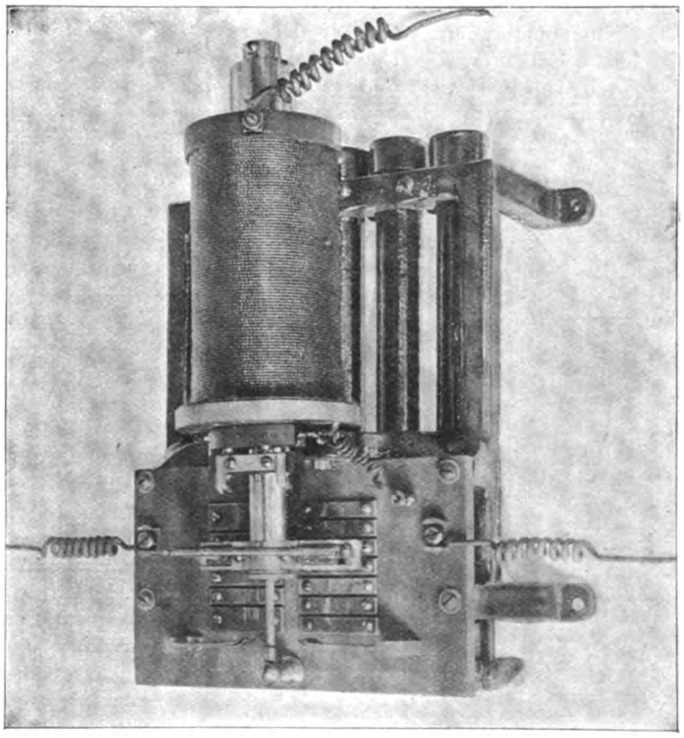
The controller casing is sufficiently protected from the entrance of moisture, and the cover instead of being hinged is arranged so that it is entirely removable, and can be set one side out of the way when it is desired to get at the internal portion of the controller.

One of the important features of the controller is the ease with which all the parts can be reached when necessary. The breaking cylinder is so designed that when from continued use the contacts have become worn, the cylinder can be turned end for end and the opposite edges of contact brought into service, thus practically completely renewing the cylinder itself.

THE WHITTINGHAM AUTOMATIC MOTOR STARTER.

The motor starter shown in the accompanying cut is designed to obviate the running of electric elevator motors, when the elevator is not in use, and is particularly adapted for freight elevators.

A rope, attached to one ring of a knife switch, is run the full length of the elevator shaft, passing over a pulley at the top and bottom of the shaft, and is connected to the other ring of the knife switch, thus making it possible to start and stop the motor safely from any floor, by simply pulling the rope. The entire installation thus can be at rest when the elevator is not actually in use, resulting in much saving of current and wear and tear on the entire outfit.



AUTOMATIC MOTOR STARTER.

The solenoid starter gradually cuts out the starting resistance when the current is turned on the motor by the closing of the switch, and cuts in the resistance again when the switch is opened.

The use of copper contacts, combined with graphite brushes, makes it impossible for the circuit closer to stick, or fuse on any of the resistance segments, even if heavily overloaded. A compression dashpot is used, and is placed directly inside of the magnet, thus reducing the length of the apparatus materially. The valve is of the "by-pass" type, and avoids the necessity of a close mechanical fit, and is not affected by grit or dirt in the oil.

The Whittingham motor starter is made by the Automatic Switch Company, Baltimore, Md.

LOUNSBURY SLOW SPEED DYNAMOS AND MOTORS.

The chief distinguishing characteristic of the type of dynamos and motors illustrated herewith is their very slow speed of operation. The 10 HP machine is run at a speed of 500 r. p. m., and the 50 HP machine at 250 revs., the speed of the intermediate and larger sizes being in the same proportion. The manufacturers state that the secret of the large output at this unusually slow speed lies in the correctness of design and proper proportioning of parts, as well as in the painstaking manner in which all details are worked out, and in the use of the best of material and skilled labor in construction.

Fig. 1. shows a 7½-HP machine that runs at 550 revs., and which is of the same design as all the other sizes, except that while this size and those smaller are four-pole, the 10-HP and larger sizes are six-pole machines.

The field rings and pole pieces are castings of a special steel, very soft, and made by a special formula for this work. The magnetic qualities are exceptionally high. There is no break in the magnetic circuit, except where the ring parts, the top half lifting off. The pole pieces are cast solid with the ring.

The armature is of the toothed Siemens type and large in diameter. The coils are wound separate from the core by special machinery, and thoroughly insulated before being put in place. They can be readily removed in case of necessity. The cores are built up of disks of No. 27 iron, carefully insulated from each other. The slots for the coils are cut in a milling machine, and the burrs carefully dressed off.

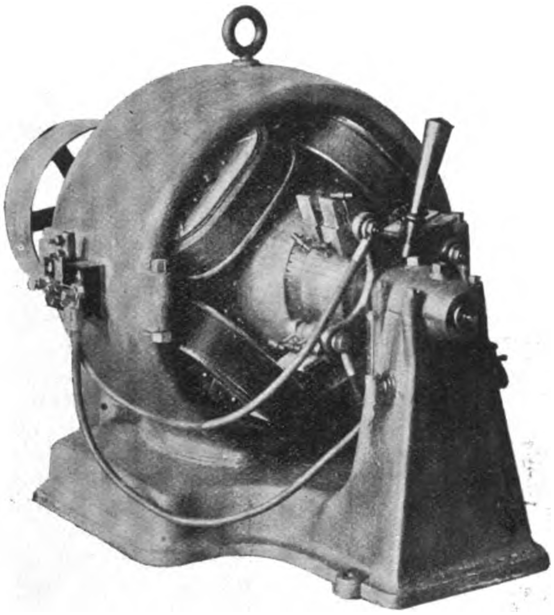


FIG. 1.—7½ HP. LOUNSBURY MOTOR.

The commutators are unusually large, with long brush surfaces and a great depth of copper. This, with the slow speed, gives a very long life and, as nearly as possible, eliminates the need of attention to commutators and brushes.

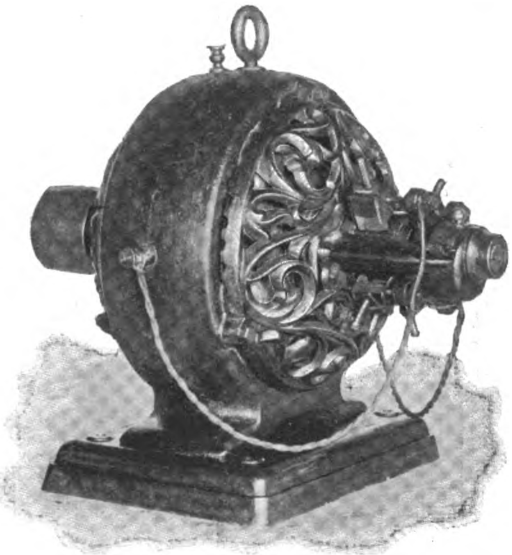
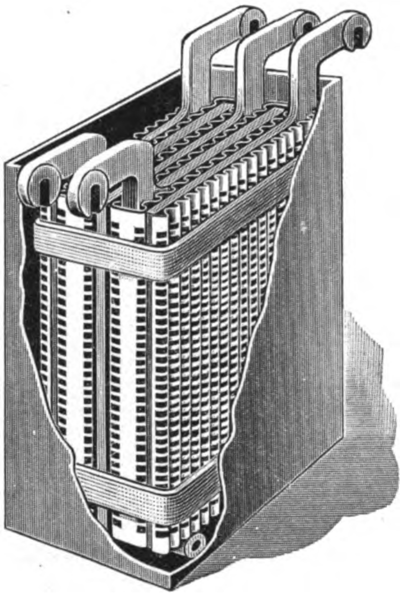


FIG 2.—1½ HP. LOUNSBURY MOTOR.

The bed is of cast iron and, with the exception of the bearing caps, is in one piece, the bearing pedestals being cast solid with the bed. Each pedestal contains a large oil reservoir, and each machine is fitted with eight oil gauges and brass oil cocks. The bearings are self aligning and self oiling, and do not require attention more often than once a month. The usual belt tightening slides with ratchets and screws are provided with each machine.

Fig. 2 shows a 1½ HP motor of the enclosed type with ornamental shields. They are also made with solid shields enclosing armature, commutator and brushes. These machines, the manufacturers state, will run successfully if entirely immersed in water.



WILLARD STORAGE BATTERY.

The above machines are made by Lounsbury & Company, 225 West Twelfth Street, Chicago, who are putting on the market a complete line of multipolar generators and motors from 1½ HP to 100 HP.

THE WILLARD STORAGE BATTERY.

The plate of the storage battery illustrated herewith consists of a piece of pure, rolled sheet lead of the thickness of the lug shown in the cut. Both sides of the lead plate, except a portion of the surface forming a rim, have cut in them deep grooves, leaving projecting shelves, at an angle to the surface of the plate, The thickness and separation of the shelves is greater or less, according to the use to which the battery is put. For permanent installations where durability is the first consideration, they are made heavy. For portable batteries where weight must be reduced to a minimum, they are made light.

A plate, 7 ins. × 8 ins., exposes a total surface of 14 sq. ft. The active material is formed directly from the lead itself, by electro-chemical means, no paint, paste, cement or pellets of any kind being used.

After being formed, the plates are encased in a hard rubber cell, or sheath, as shown in in the cut, which is thickly perforated with holes, thus offering no resistance to the passage of the electrolyte; the separator is substantial, making a thick, hard rubber cell, all in one piece.

The advantages claimed for the Willard battery are that plates are extremely flexible; they can be bent into the shape of a letter S without damaging them in the least, and after being straightened, they are as good as ever. That the active material is nowhere more than a $\frac{1}{32}$ in. thick, and, consequently, is in intimate contact with the leaves and core forming the body of the plate, which insures low internal resistance throughout the complete discharge. That the leaves or grooves, being corrugated from edge to base and set at an angle, prevent the loosening of active material. That the plate is made in such a way as to provide a space for expansion; every five leaves, or grooves, there is left a wider groove, and in forming, this groove is not filled entirely full of active material like the others, thus leaving a space to allow for expansion. The Willard plates are made entirely by machinery, no hand work being required. The battery is made by The Electric & Battery Company, Cleveland, O.

THE ROYAL ELECTRIC ALTERNATOR.

The type of alternator illustrated in Figs. 1, 2 and 3 is the earliest type of inductor machine made in this country, having originally been placed on the market as early as 1890. Fig. 2 shows the machine complete. On a solid frame are mounted the bearings, and (as seen in Fig. 1) also the skeleton spider for receiving the laminated blocks of the armature. The latter are bolted to the spider and surround the shaft concentrically. At the extreme ends of the laminated blocks are mounted the lathe wound armature coils, which, owing to their favorable position, can be heavily insulated.

It will be observed that neither the thickness nor the length of the armature coils interferes with the length of the air-gap or the magnetic circuit. They may, therefore, be made of the shortest linear dimensions, and their resistance can be made very low. They are very accessible, but this feature, however agreeable from a point of construction, is of no great weight, as the burning out of a coil is a rare occurrence. It seems that lightning has been the only cause of damage to a few coils out of a great number of machines in operation.

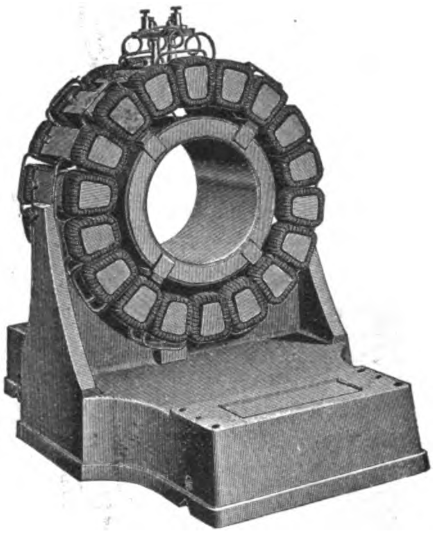


FIG. 1—ROYAL ARMATURE.

Centrally between the armature coils is mounted a single field magnet spool, which is firmly secured to the armature spider. The terminals of this field winding are carried to the small binding posts, shown on the terminal board situated on small iron columns on top of the machine. The larger terminals are those into which the circuit wires are to be connected, and to which the ends of the two sets of armature coils are secured. Each side of the armature shows eighteen coils, neighboring coils of which are connected in opposite direction. In front of these coils rotate the pole extensions of the core, which are shown in Fig. 3. The core, which occupies the central opening visible in Fig. 2, has butting on to its ends the two star-shaped core parts mounted on the shaft. The opening between the pole extensions is closed by wooden blocks, firmly secured to the plates to prevent air currents. It will be noticed that the poles are but nine on each side, so that half the number of coils are covered by them. The central wrought iron magnet is energized by an exciter of horse shoe type, and the flux produced passes from the pole extensions alternately into successive groups of laminated blocks, and induces the alternating current, according to well known laws. The armature coils are wound so that each side gives a pressure of 1000 to 1100 volts. Therefore, if connected in parallel, each side has to carry but one-half the current capacity of the machine. Again, if it is desired to have 2000 volts at the terminals, the two windings are connected in series. The smaller machines of 500, 650 and 750-light capacity have sixteen coils instead of eighteen, as shown on the 1000-lighter, and these can be so connected as to be used without transformers at 110 to 120 volts or 220 to 250 volts.

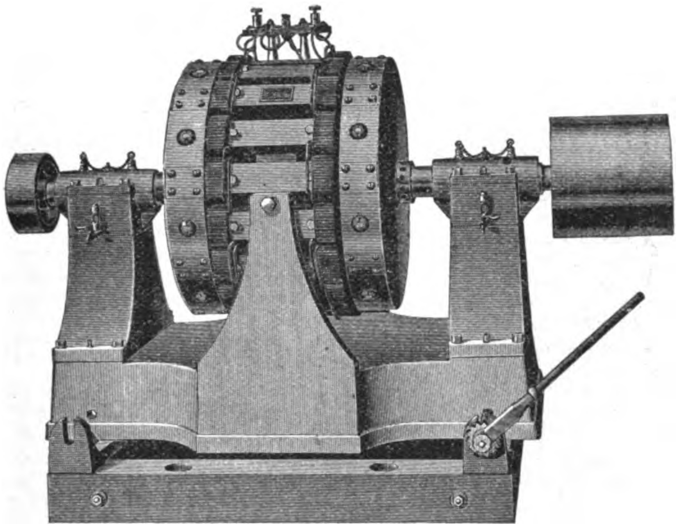


FIG. 2.--ROYAL ALTERNATOR.

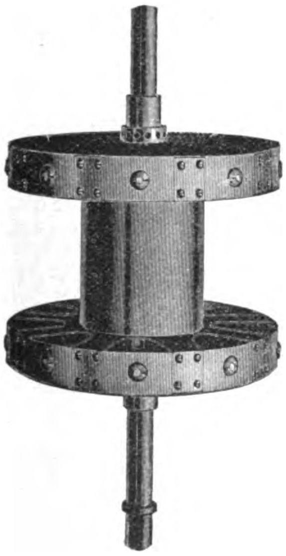


FIG. 3.—INDUCTOR.

Another advantage offered by this alternator is that, without changes of a mechanical nature, such as securing of two alternators on to the same shaft, as has been frequently suggested in technical journals, this same machine may be changed into a two-phased alternator by connecting alternate coils into two separate circuits.

Last, but not least, owing to the stationary high-tension terminals and no moving wires, this machine can be and has been intrusted to unskilled hands, and gives excellent performance. The men experience no trouble at all in running the machine and handling the currents.

A few data, taken at random from the test book of a 1000-light dynamo, gives the following extremely favorable figures :

PRIMARY.			EXCITER.			Percentage of Excitation
Amp.	Volts	Watts	Amp.	Volts	Watts	
46	1,000	46,000	4.62	40	184.8	0.4
3,852	1,050	40,446	3.8	33	125.4	0.3
2,575	1,050	27.037	3.	28	84.	0.3

Fig. 4 gives the small switchboard for a single unit. The right hand side shows the voltmeter, which is connected to the switchboard transformer, shown to the left on the center panel. Below this instrument is located the exciter rheostat, of which only the contact points are placed on the front of the slate. In the center slab, below the transformer, are the main line fuses; below these the ground detector. On the left hand panel are situated the ammeter and the main circuit switch. For the latter, of course, depending on the number of circuits, would have to be substituted a double-pole, double-throw switch, if the circuits are more than one, or if two or more dynamos are feeding into the circuits. Every additional unit may be added without interfering with the look of the switchboard, by adding panels sideways. For larger stations in which a greater number of circuits and units are to be installed, the circuit arrangements are reduced to the simplest form.

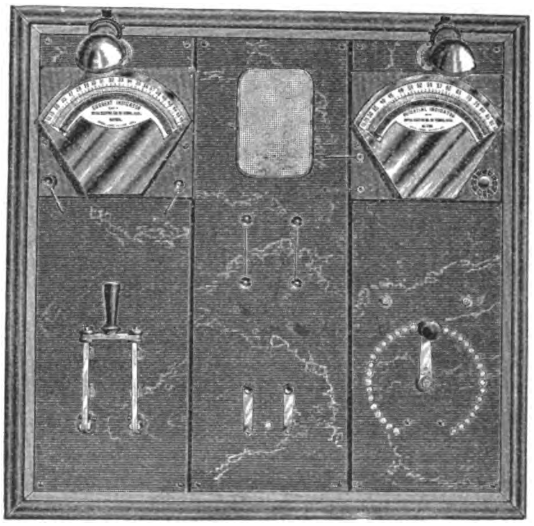


FIG. 4.—SWITCHBOARD.

The above machine is made by the Royal Electric Company, of Peoria, Ill., which company also manufactures transformers and a complete line of direct-current apparatus.

NEW BOOKS.

HOW TO MAKE AND USE THE STORAGE BATTERY. By P. B. Warwick. Lynn. Bubier Publishing Company. 140 pages, 22 illustrations. Price, $1.50.

The contents of this book vary widely in character, most of them having little reference to the title; the chapter on "How to Make a Practical Storage Battery," in fact, comprising less than seven pages. The chapter on "How to Install, Work and Maintain a Storage Battery" contains considerable useful information though mixed up with a table of metric measures, an explanation of thermometric scales, chemical data, etc. The other contents consist of a list of storage battery patents and descriptions of some forms of cells.

ELECTRICITY IN ELECTRO-THERAPEUTICS. (Elementary Electro-Technical Series). By Edwin J. Houston and A. E. Kennelly, New York. The W. J. Johnston Company. 462 pages, 128 illustrations. Price, $1.00.

To the physician who desires to obtain a correct knowledge of the electrical principles concerned in electro-therapeutic apparatus, this book will be of the greatest value, while it will be of much interest to the electrical reader, and not beyond the reach, owing to the non-technical method of treatment, of the general public. All of the various kinds of electrical medical apparatus are described, and the several forms of electrical currents, such as direct, symmetrical and unsymmetrical, alternating, high frequency, etc., are clearly explained, as well as static discharges, electrolysis, cataphoresis, etc.

TRADE PUBLICATIONS.

Multipolar Motors and Generators. The E. & C. Electric Company, Cleveland, O., has issued a pamphlet describing its Type "D" multipolar generators and motors. By means of a patented adjustable base, these machines may be bolted to the wall or the ceiling, and will operate as successfully in these positions as when placed in the normal position on the floor.

The Fashioning of a Lamp. Under this title the Bryan-Marsh Company, 136 Liberty Street, New York, has issued a beautifully bound pamphlet in which Mr. Maurice Hyde Cleveland describes the various processes employed in the manufacture of incandescent lamps. In an appendix no less than fifty-four different forms of commercial incandescent lamps are illustrated, all of which are regularly made by the Bryan-Marsh Company.

Air Brakes. In a handsomely printed and cloth-bound volume, the Standard Air Brake Company, of 100 Broadway, New York, describes in full detail its well known air brake system for electric cars, freight cars and locomotives, cable cars, lift bridges, etc. All of the various details of the brake are illustrated and clearly described, as well as some specimen installations. A large folder shows the arrangement of the several parts of the system as used on a motor car with a trailer.

I-T-E Circuit Breakers. The Cutter Electrical & Manufacturing Company, 1112 Sansom Street, Philadelphia, has issued a luxurious catalogue describing the I-T-E (inverse-time-element) automatic magnetic circuit breakers which it manufactures under the Harrington fundamental patents. Circuit breakers for switchboards, railways, light and power, motors, motor cars, house service and storage batteries are illustrated and described. The portions of the pamphlet dealing with the principles of magnetic circuit breakers will be found instructive.

Lead Pipe Fittings. The Van Auken Steam Specialty Company, 201 Canal Street, Chicago, has issued a twenty-four page catalogue describing the various details of its modern mechanical system of connecting lead pipe to lead pipe, or lead pipe to iron or appurtenances, which system obviates the use of soldering and wiped joint. The same firm illustrates some of its steam specialties, such as steam traps and valves, on a handsome celluloid 45 deg. triangle, each of the three edges of which contains a scale. This useful draughting tool or desk convenience will be sent by the Van Auken Company to any of our readers who mentions the AMERICAN ELECTRICIAN.

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BUSINESS NEWS.

H. B. Coho &Company, 203 Broadway, New York, have been awarded the contract for the St. Paul Building electric plant, two 100 KW and one 50 KW Eddy machines will be installed.

The Van Auken Steam Specialty Company, 203 S. Canal Street, Chicago, Ill., made a large shipment of Monash regulators to Berlin and to Copenhagen, Denmark, last month. Large shipments of Fidelity steam traps and Star pipe wrenches are also reported.

The Penberthy Injector Company, Detroit, Mich., has increased its line of goods, and is sending injectors of all kinds to every part of the world, the company recently having entered the foreign market. The company publishes a neat little publication called the "Penberthy Bulletin," which is well worth asking for.

Gates of Chicago has opened commodious salesrooms at 311 Dearborn Street, Chicago, with a complete stock of C. & C. Electric Company's dynamos, motors and appliances. Mr. Gates is meeting with success in the sale of these well known dynamo electric machines. Special applications of motors to tools, cranes, elevators, pumps, hoists, etc., are the great forte of the C. & C. Company.

The Triumph Electric Company, Cincinnati, O., has been in its new quarters only about four months, and though some four times the size of the old factory, it already begins to find them none too large. Trade has recently been very heavy, and orders continue coming in rapidly. The company is now installing four direct connected outfits, the largest being 150 KW and the smallest 15 KW.

A Healthy Sign. The Washington Carbon Company, Pittsburgh, Pa., is making important additions and improvements in its two factories, including the addition of a number of grinding, crushing and milling machines. We understand that large contracts recently taken, in addition to the company's motor brush and cored carbon business, have made this expenditure an imperative necessity.

How to do Away With Wiping or Soldering Lead Joints. The Van Auken Steam Specialty Company, 203 South Canal Street Chicago, Ill., will be pleased to send a pamphlet to any reader of the AMERICAN ELECTRICIAN, from which a thorough understanding may be obtained of the new and simple method by which couplings are used instead of solder in making lead to lead, and lead to iron, pipe connections.

The Cummings Conduit Company, Detroit, Mich., has just completed the underground work it has been doing for the Englewood Electric Light Company and the People's Electric Light & Motor Power Company, Chicago. The current has been turned on, and everything is working very smoothly. 6000 volts is being carried for the People's Company on bare copper wire, and 2000 volts alternating for the Englewood Company.

The Ohio Electric Works, 13 South Water Street, Cleveland, O., have begun the manufacture of an electric bicycle lamp that is warranted to remain lighted and to last. The general appearance of the new lamp does not differ much from that oil lamps except that it is narrower, and the reflector, which holds the small incandescent lamp, projects further to the front. The charge for the cell is bought in packages, each of which is sufficient for a renewal.

The Chas. E. Gregory Company, Chicago, reports brisk business for May, Among the sales for that month were seven Edison dynamos, of 45 and 6 KW, and 250, 210, 15 and 25 lights—two of the latter; four Mather motors of 50, 10, 6 and 5-HP; five U. O. dynamos, one of 50 and two each of 180 and 250 lights; one 75 light Eddy machine; two 50-light T-H. arc machines and one 35-KW T-H. alternator. In addition, a large number of smaller machines and large quantities of arc lamps, transformers etc., were sold.

Graphite in Electrical Work. The Joseph Dixon Crucible Company, Jersey City, N. J., in a recent circular describes the various uses of graphite in electrical work. Among uses to which it has thus been put are in the manufacture of graphite rods of 1½ to 3 ohms resistance for use as motor brushes; resistance rods varying from 1½ to 500 ohms; graphite rods and plates for batteries; graphite boxes for burning carbon filaments, etc., electrotyping graphite. For the operation of electrical machinery there are graphite lubricants, and graphite paint for electric light poles and iron work.

The Sunbeam Incandescent Lamp Company, Chicago, has recently purchased a new factory located at Desplaines, Ill., a few miles west of Chicago. The factory is a substantially built brick structure, and will give the Sunbeam Company about double the floor space of its present factory. It will be fitted up with all of the very latest devices used in the manufacture of lamps, which will give the Sunbeam Company facilities that are second to none, and a largely increased capacity. A special department will be fitted up for the manufacture of Sunbeam X-ray tubes, for which there is now a steady demand,

The Metropolitan Electric Company, Chicago, Ill., is highly elated over the success of its voluminous catalogue. It has had orders for the book from Her Majesty's Government, Turkey in Asia, the gold fields of Johannesburg, Australia, Central and South America, and pretty much around the entire globe, and wherever it goes it brings the highest encomiums for its comprehensive character and attention to details. Those that are interested in electricity in any way should get a copy, as this catalogue is a great help as a "ready reference book" and an "encyclopedia of everything electrical."

The Hercules Boiler Oil Injector, manufactured by F. H. Cornell & Co., 469 West Fourteenth Street, New York City, for feeding kerosene oil to boilers to prevent scale, seems to have struck the foreign markets like a whirlwind. They are being shipped in large quantities to nearly all the countries of Europe, as well as to Asiatic Russia and Turkey, Japan and Australia; not in single ones but in lots of ten to fifty at a shipment. England, France, Germany, Belgium, Austria and Japan are the largest consumers. Mexico and South American countries are using them quite largely. The manufacturers have their catalogues printed in English, French, German and Spanish.

The Standard Underground Cable Company, of Pittsburgh, Pa., announces, that it has completed arrangements whereby it is enabled to undertake the installation of underground systems complete in every detail. A conduit department has been established of which the manager is Mr. F. S. Viele, an unusually well experienced practical engineer in conduit and cable construction. The company is prepared to furnish quotations for the equipment of underground systems with cement lined pipe, vitrified clay, or wooden log conduit, and for systems complete in every detail, including conduits, manholes, hand holes, cables, junction boxes, etc.

The Chicago Rawhide Manufacturing Company, Chicago, Ill., is just in receipt of its World's Fair medal and diploma, given it upon the merit of its excellent exhibit. The medal is bronze and of a handsome design. The award reads as follows: "Exhibits of rawhide belting, of rawhide rope belting and of rawhide lacing are highly meritorious. The belts are from well selected stock of even thickness, soft and pliable when new, of good adhesion, and in every respect well made. The twist belting is made from three-eighths of an inch in diameter, down to one-thirty-second of an inch in diameter, and is of excellent uniformity and thickness. The leather is prepared without the use of lime or acids, the hair being removed by sweating."

The Michigan Electric Company, of Detroit, Mich., has just moved into new quarters at 101 Woodward Avenue. The new location is on the main thoroughfare in the heart of the city, and has many advantages not found at the old quarters. This move gives the company an entire building, which it occupies throughout with its offices, storerooms, salesroom, etc. The arrangement of the different departments is complete in every way, everything having been designed with special reference to facilitating business. A novel feature, which will, no doubt, prove very popular with the company's customers, is a reading room, in which will be found all of the periodicals of interest to men in the electrical business. The company had a formal opening of its new building on the evenings of May 30 and June 1.

The M. C. Bullock Manufacturing Company, of Chicago, has recently installed in the power plant of the Pabst, Heat, Light & Power Company, of Milwaukee, two engines for direct coupled, alternating current two-phased work. The engines are of the Willans central valve type, compound, automatic, non-condensing, 150 lbs. pressure, and are guaranteed to give an economy of less than 21 lbs. per I. HP. The two units are of 200 I. HP and 400 I. HP capacity, and form, with the Westinghouse alternators, a most compact and efficient plant. The plant was installed by the Pabst Company on the basis of economy of operation viewed from all the standpoints of central station work, including economy of space, attendance and continuous running for long periods of time with a minimum amount of attention. The results fully justify the time and labor devoted to this problem by the general manager, Mr. Parker, and his consulting engineers.

The Keystone Electric Company, Erie, Pa., has found it necessary, in order to accommodate its rapidly increasing business, to build a two story, 42 ft. × 56 ft. addition to its factory. In addition to this the company is also putting up a testing room, 46 ft. × 66 ft., together with a blacksmith shop and pattern storehouse. This move has been made necessary on account of the expanding business of the company, and when the buildings are all completed it will make an equipment complete in every detail, and will give facilities for testing not had heretofore. The ground floor of the new building will be used as an extension of the machine shop. The second floor will be utilized for armature winding, etc. The equipment of the shop will be with individual motors, doing away with all line shafting. For testing purposes, a 200 HP engine and boiler will be installed. The main machine shop and testing rooms will be equipped with traveling cranes to handle all heavy work. The building is being constructed so that additions, if found necessary, can be made in the future.

A Working Exhibit. The operative exhibit of the J. H. McEwen Manufacturing Company, installed at the Electrical Exposition held at the Grand Central Palace, New York, during the month of May, and consisting of a forty kilowatt Thompson-Ryan multipolar generator direct connected to a 10 × 10 McEwen engine received its due share of attention from the engineering profession and others who visited the show. Its compactness, pleasing outline and smooth running drew many highly complimentary remarks from the thousands of visitors, and in order to satisfy those who were interested from a practical standpoint, a water rheostat was provided so that any desired load up to fifty per cent beyond the rated capacity of the dynamo could be thrown off and on at will. The normal capacity of the dynamo is 320 amperes at 125 volts, and the test of throwing on and off 450 to 475 amperes instantly, with absolutely no sparking and without racing of the engine, was a great surprise to all who witnessed the tests. Catalogues describing the above machinery may be obtained free by addressing the company at No. 20 Dey Street, New York.

The Electric Appliance Company, Chicago, has brought out two more clever and original advertising schemes in the shape of a pad or tablet of blank forms on which can be recorded thirty minute readings of the number of amperes as shown by a station ammeter. This gives a permanent record of the station load at thirty minute intervals during the entire twenty-four hours. Its other scheme is a complete set of architect's specifications for electric wiring, which can be used as a form for making contracts for electric wiring. These specifications have been carefnlly drawn by a well known consulting electrical engineer and will be found valuable guides in all electric light work. Either or both of these will be furnished free on application. This company has succeeded in producing, by a few slight changes in the regular Upton arc lamp, a lamp that will burn for thirty hours, with a single pair of carbons. This lamp is meeting with much favor, and will probably largely displace the regular ten, twelve and fifteen hour lamp. In addition to its great convenience, the question of its greater economy is a point not to be overlooked.

American Electrician.

Vol. VIII. New York, July, 1896. No. 3.

ELECTRICAL TRANSMISSION OF POWER IN CALIFORNIA.

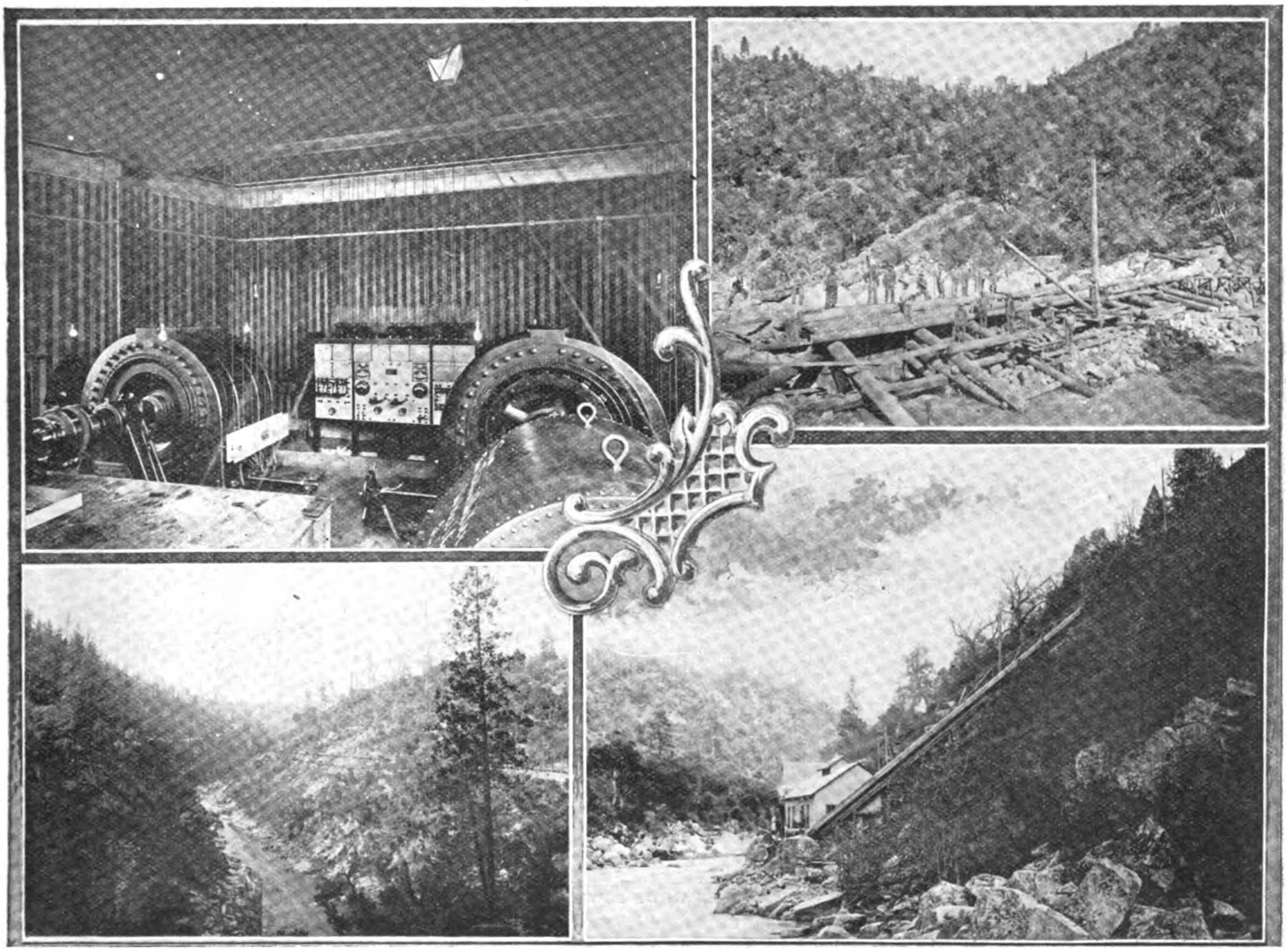
BY W. F. C. HASSON.

ONE of the most important mining districts in the State of California, is that located in Nevada County. Thirty years ago, work was started on the development of a great group of mines, and large quantities of ore were taken out. However, as the mines became deeper, the difficulty of handling the water which filled them had to be encountered. Steam pumping plants were installed, and all of the first growth of timber in the vicinity used as fuel. Ditches were built, and water power plants installed to operate the mines. Many of the mines were located so high up in the mountains, that it was impossible to reach them with water power, without obtaining it above the snow limit. The result was an uncertain power during a fair portion of the year. On account of the cost of power, many of the mines were shut down, and gradually filled with water, and the two thriving towns of Nevada City and Grass Valley, from being busy mining centers, gradually settled into sleepy inactivity.

Several years ago, Mr. A. Tregidgo, a mining engineer of great energy, took up the idea of an electric transmission of water power, to be obtained by damming the South Yuba River. He had many difficulties to encounter, as the country is extremely rugged and the mountains precipitous, necessarily making surveys a matter of great expense. The gold that had been taken from the mines, had been converted into money, and no longer remained in Nevada County. The successful operation of mining machinery with electric motors was not as yet an established fact, and it was difficult to obtain confidence and to enlist capital. The large companies owning the ditch lines that supplied water power, thought they foresaw a diminution of their revenues, and endeavored in every way to destroy confidence in the proposed electrical transmission of power scheme.

A thorough canvass was made of all the mining properties, and the amount of power required for various purposes estimated; it was shown that the machinery operated by steam power at extravagant rates, together with that lying idle for want of ecomonic power, was far in excess of the capacity of the proposed plant.

Finally, in 1892, Mr. Tregidgo succeeded in enlisting capital sufficient for the construction of a dam. Work on the dam was started late in the season, and pushed with all possible rapidity; but when about two-



GENERATOR ROOM. THE DAM UNDER CONSTRUCTION.
FLUME ALONG MOUNTAIN HILL. THE POWER HOUSE.

FIG. 1.—NEVADA COUNTY (CAL.) ELECTRICAL TRANSMISSION PLANT.

thirds completed, an early storm brought a freshet in the torrential stream, which destroyed the dam, the confidence of the capitalists who had furnished the money, and everything except the energy and self-confidence of Mr. Tregidgo.

The financial condition of affairs for the next two years was such as to prevent any further progress with the proposed scheme, and it was not until the spring of 1895, when the electrical transmission of power had become an assured fact, that some of the wealthy mine-owners whose mines were lying idle, took up the matter and advanced the money necessary for machinery and construction. A contract was closed with Mr. John Martin, the San Francisco agent for the Stanley Electric Company, for the generators and the construction of the pole line. The Pelton Water Wheel Company took the contract for water wheels. The details of the engineering work were placed in the hands of Mr. William R. Eckart, and the firm of Hasson & Hunt.

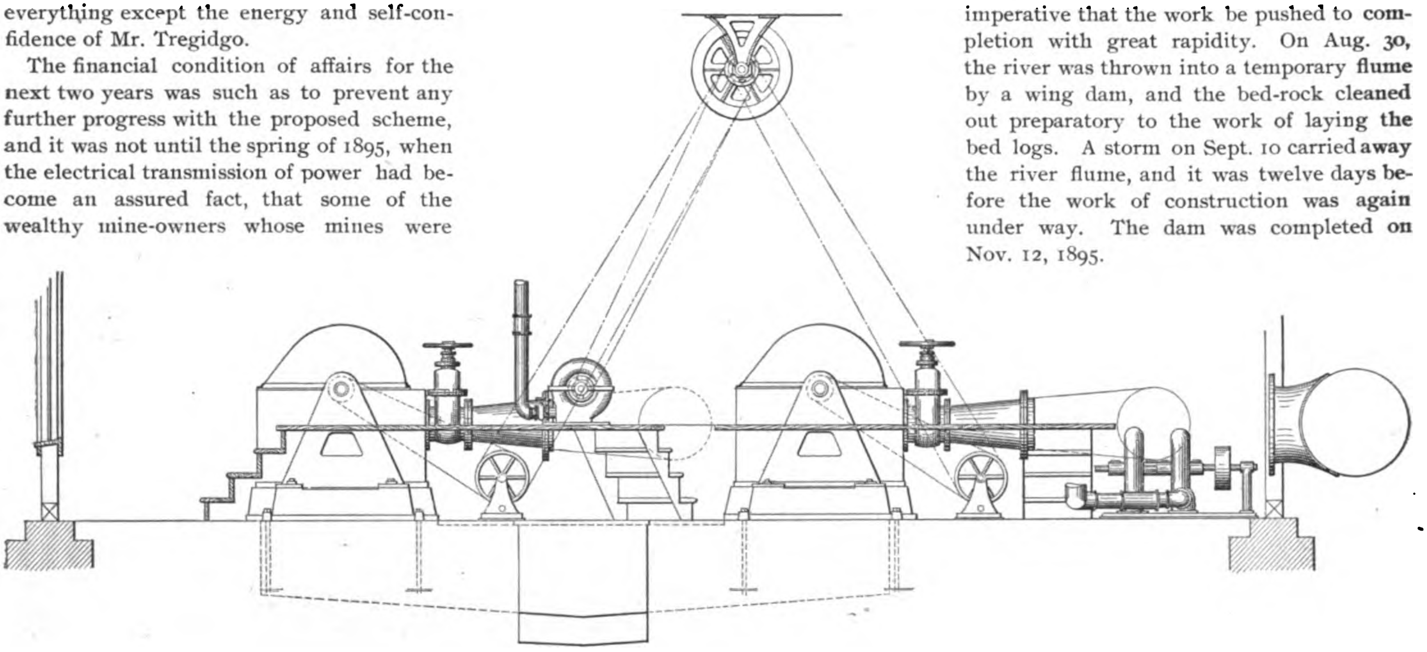


FIG. 2.—ELEVATION OF POWER HOUSE.

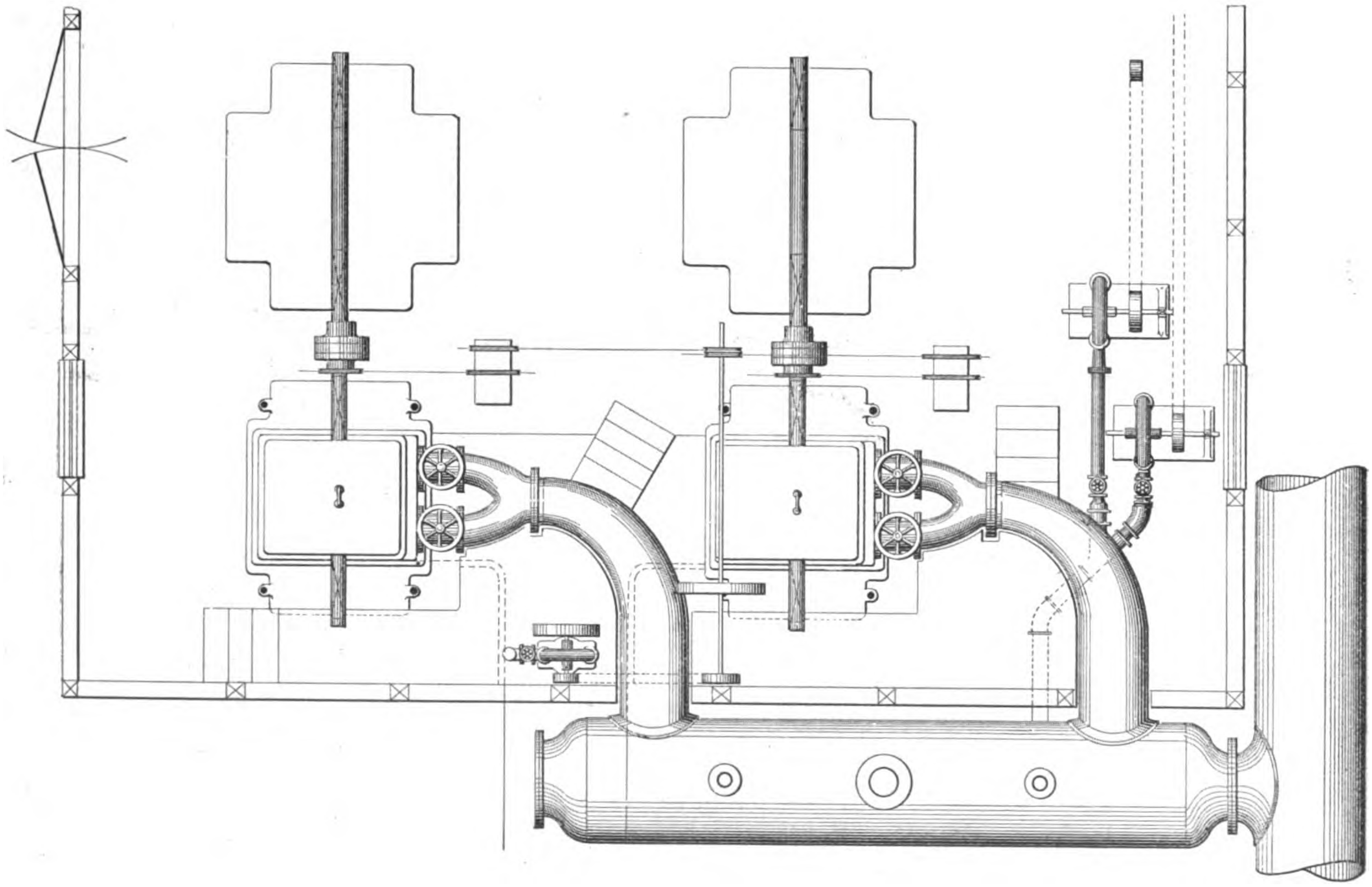


FIG. 3.—PLAN OF POWER HOUSE.

The first problem was the construction, with materials at hand, of a dam of assured strength to meet the circumstances of a torrential stream. This question was taken in hand by Mr. Hunt and Mr. Eckart, and a cribbed log dam, in which each individual log was bolted back to the bed-rock, was decided upon as being a type that would stand the accident of an early freshet without being carried away.

The period for the construction of the dam being necessarily limited, it was rendered imperative that the work be pushed to completion with great rapidity. On Aug. 30, the river was thrown into a temporary flume by a wing dam, and the bed-rock cleaned out preparatory to the work of laying the bed logs. A storm on Sept. 10 carried away the river flume, and it was twelve days before the work of construction was again under way. The dam was completed on Nov. 12, 1895.

The dam is 31.3 ft. in height, 206 ft. along the crest, and loaded with about 6000 tons of granite rock blasted out of the adjacent mountains. This work was pushed night and day by Mr. Tregidgo, and is unquestionably an example of very rapid construction. Within a short time after the completion of the dam, a heavy freshet put water nine feet in depth across its entire top, without the dam showing any indications of weakening.

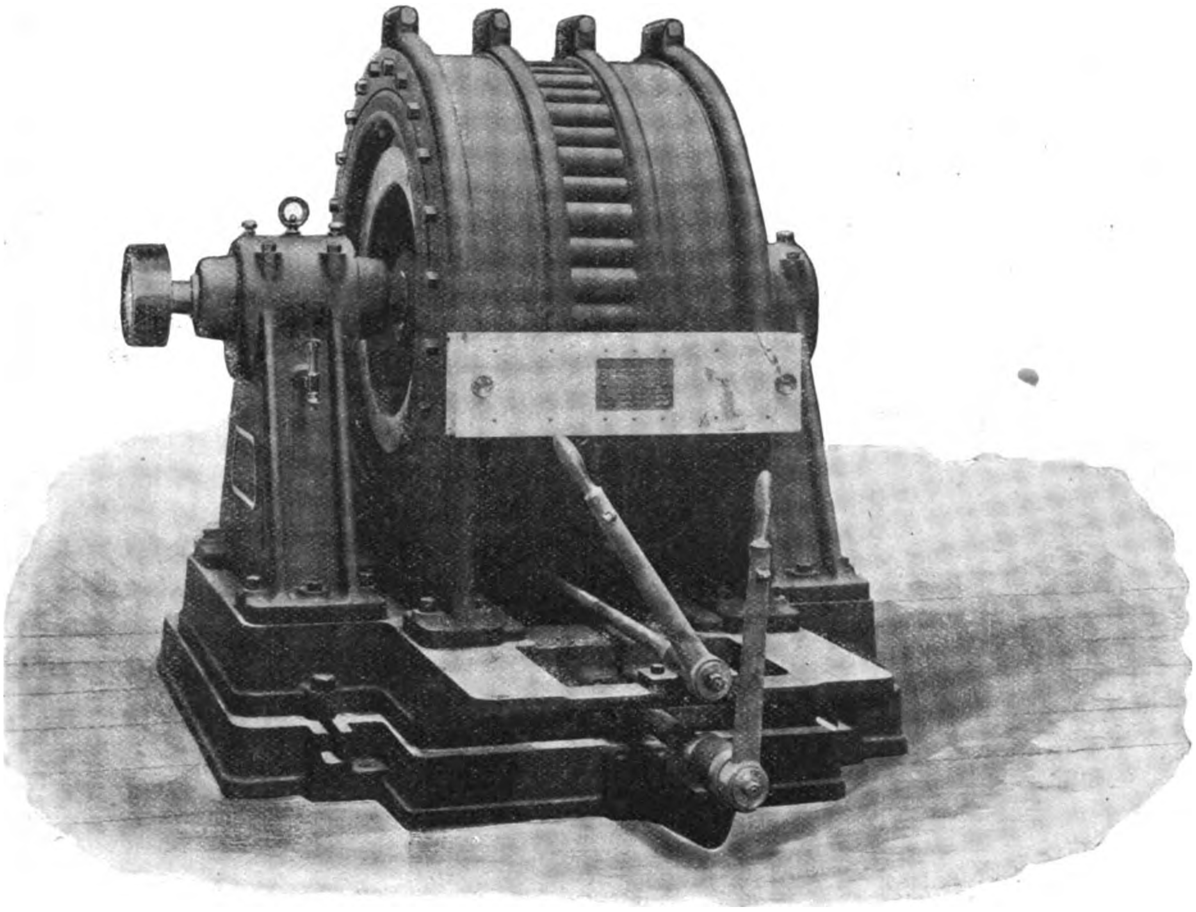


FIG. 4.—TWO-PHASED GENERATOR.

From the dam, a flume was carried along the mountain side a distance of 18,340 ft. to the power house site. The angle of the slope of the mountain along the greater portion of the extent of the flume, is about 40 degs., and where the flume did not rest upon a slippery slope of solid granite, the work had to be carried through a dense undergrowth of manzanita.

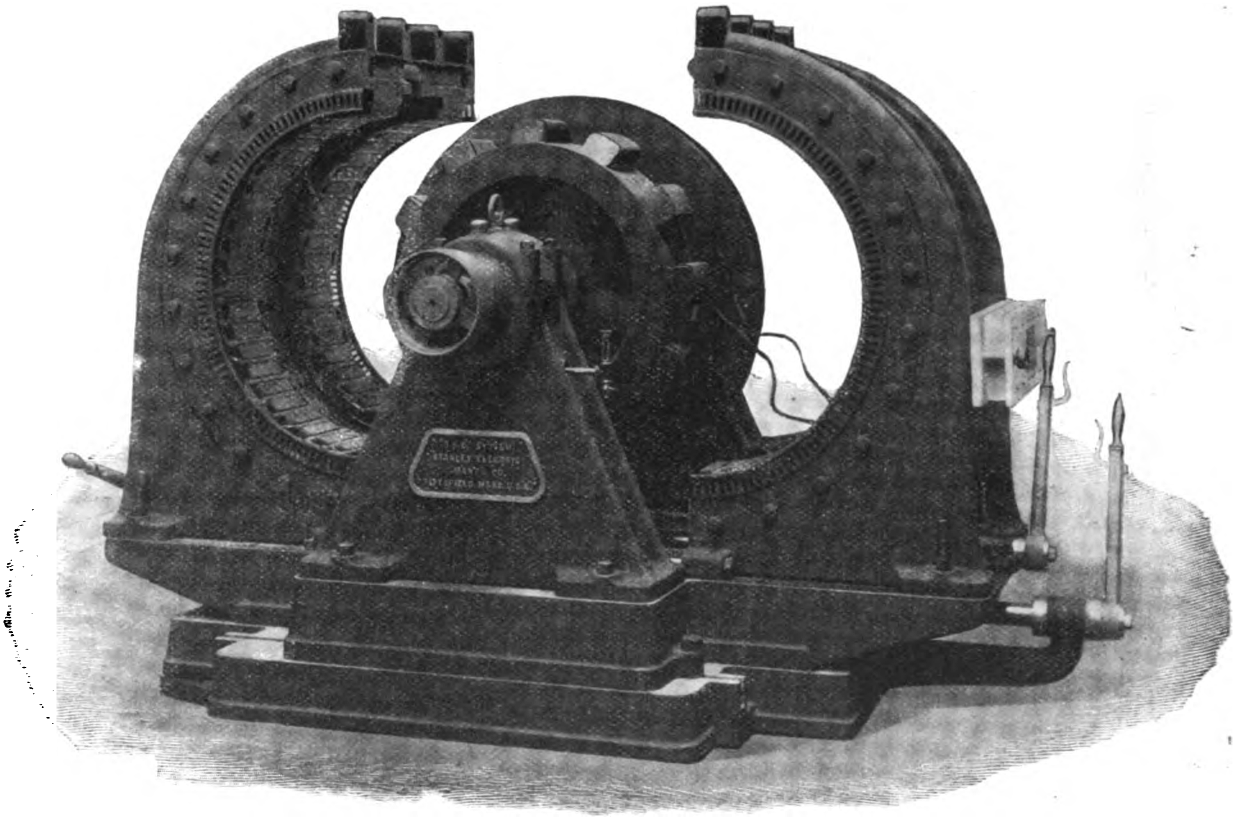


FIG. 5.—GENERATOR, ARMATURE FRAME PARTED.

The power house is located sufficiently above the bed of the river to be above danger of high water, and at the foot of a mountain having a rise of 1000 ft. in a distance of 1700 ft. A road was built as far as practicable down the mountain side, and the machinery was hauled within 900 ft. of the power house, from which point it was snubbed down the precipitous mountain side.

The machinery consists of two 320-KW Stanley-Kelly two-phase generators, each of which is directly connected to a Pelton water wheel having a capacity of 500 HP. The generators are driven at a speed of 400 r. p. m. delivering current at an E. M. F. of 5500 volts and 16,000 alternations. The exciting current is supplied by two 6-KW direct-current generators, driven by independent water wheels.

The water is carried from the penstock to the receiver at the power house, through a pipe fifty-five inches in diameter at the top, and forty-two inches at the bottom, the vertical head being 206 ft. The anchoring of the pipe was attended with considerable difficulty, due to the fact that the side of the mountain proved to be composed of disintegrated granite to a very considerable depth. The greater proportion of the power house site was blasted out of solid granite.

The first pipe supplied by the contractor was rejected by the engineers as failing to fulfill the specifications and being so poorly constructed as to be dangerous. The result was a delay in starting the plant which was finally accomplished on Feb. 4, 1896, since which date an uninterrupted commercial service has been given to Nevada City, distant four miles, and Grass Valley, distant eight miles (Fig. 10). Mine owners were desirous of seeing the power actually delivered before contracting for motors, and this delayed for some time the development of the motor service. This, however, is now rapidly progressing, and a new area of light, activity and prosperity has come to Nevada County.

The cost of dam, flume, pipe line, power house, hydraulic and electric machinery, and eight miles of transmission line, was $99,700.

EQUIPMENT OF THE NEVADA COUNTY PLANT.

The general arrangement of the Nevada County plant is shown in Figs. 2, 3 and 4, and the type of Pelton wheel installed is illustrated in Fig. 9. The coupling to which the generator is attached is seen on the left, the generators being seated on an extension of the bed-plate. Regulation is afforded by Pelton differential governors, one of which is shown mounted on the base in the illustration.

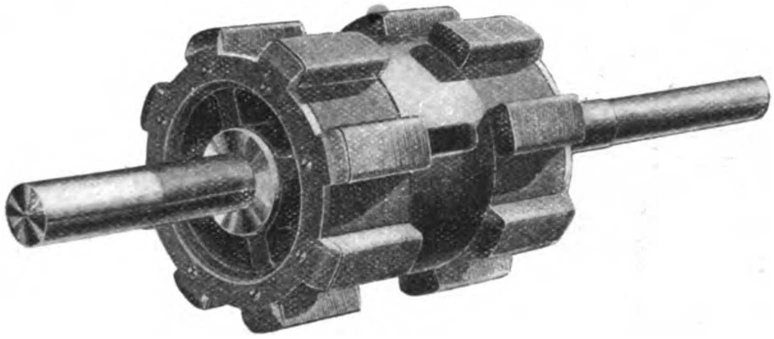


FIG. 6.—INDUCTOR OF TWO-PHASED GENERATOR.

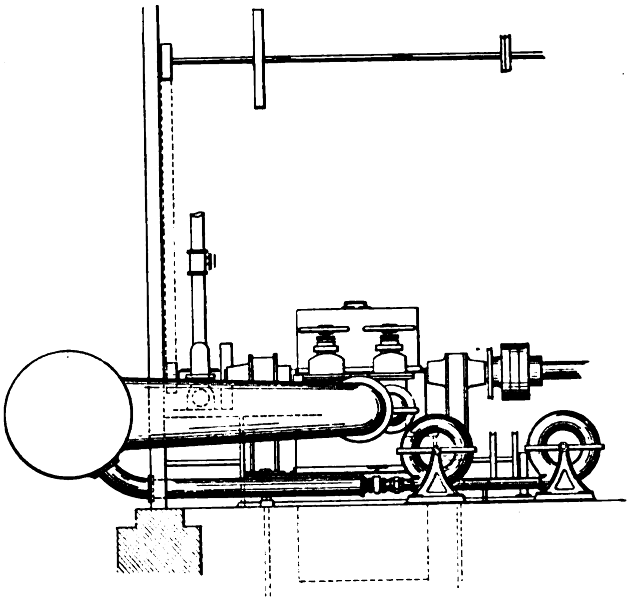


FIG. 7.—SIDE ELEVATION OF POWER HOUSE.

The type of generator is shown in Figs. 4 and 5, the latter with the armature pulled apart. The armature and field coil are stationary, the only movable part being the steel inductor, shown in Fig. 6. The armature coils are mounted in two crowns (Fig. 5), each forming the generating circuit of one of the two branches or "phases" of the two-phased line. The terminals come to the marble terminal board shown in Fig. 4, which consists of two slabs, one secured to the machine and the other forming a removable cover. Partitions between the two slabs divide the space into compartments, so that each terminal has a compartment by itself.

The stationary field or exciting coil is shown in Fig. 5; it is wound on a copper spool and rests on the center of the machine surrounding the inductor. Being enclosed on three sides by the heavy copper spool, danger of breaking down the insulation from a discharge caused by breaking the field circuit when fairly charged, is practically obviated.

The generators are operated at 5500 volts without step-up transformers, and are run in parallel. Of course, the breaking of a circuit worked at such a high E. M. F., is a somewhat difficult matter, and for that reason all the switches on the board (Fig. 8) are es-

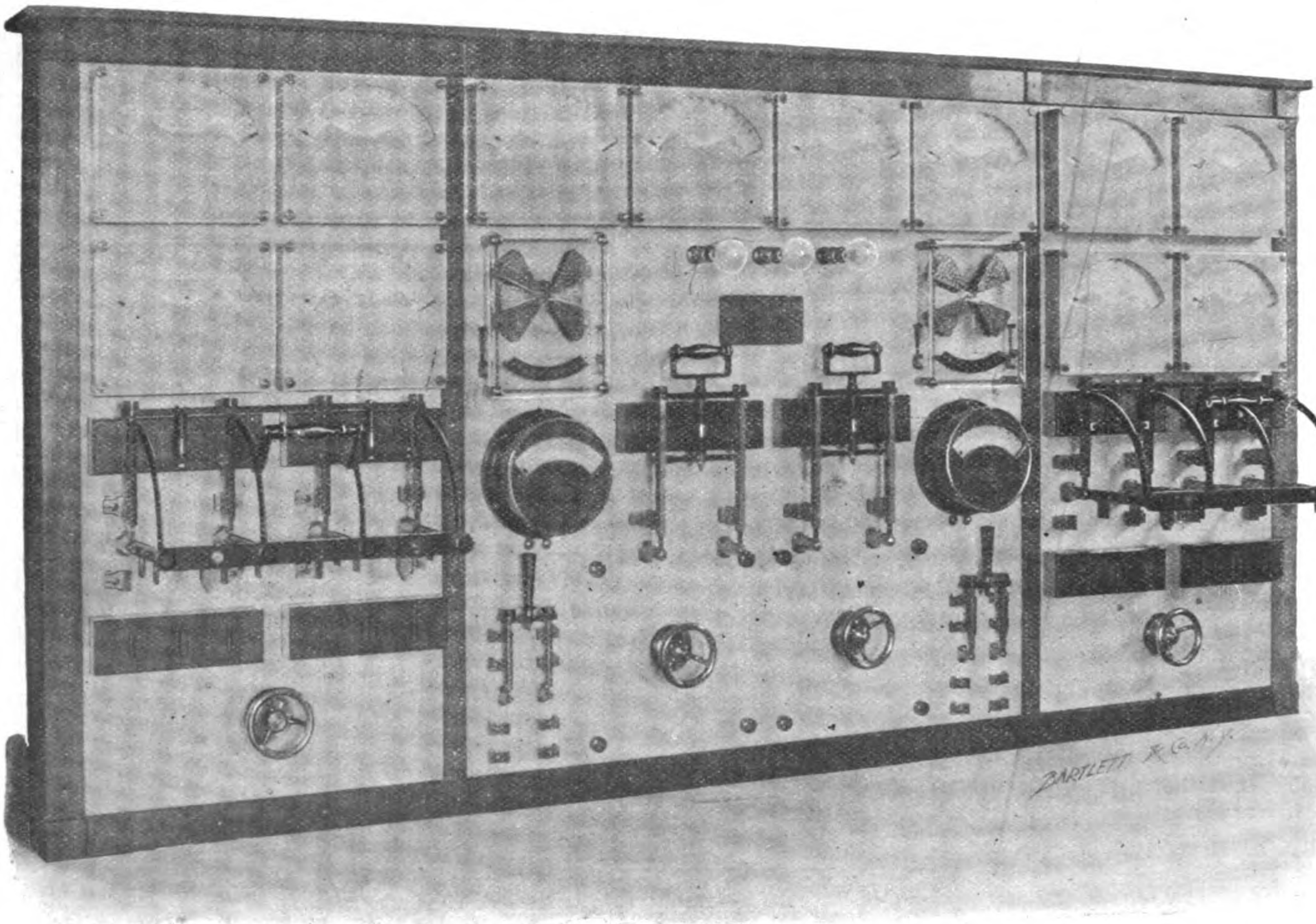


FIG. 8.—SWITCHBOARD.

pecially designed. Arcing is prevented by enclosing the jaws of the switch in a box with only a narrow slit to allow the blade to enter, and this slit is automatically covered by a slide immediately on the withdrawal of the blade. The static ground detectors shown in the illustration of the switchboard, are based upon the principle of the Kelvin quadrant electrometer.

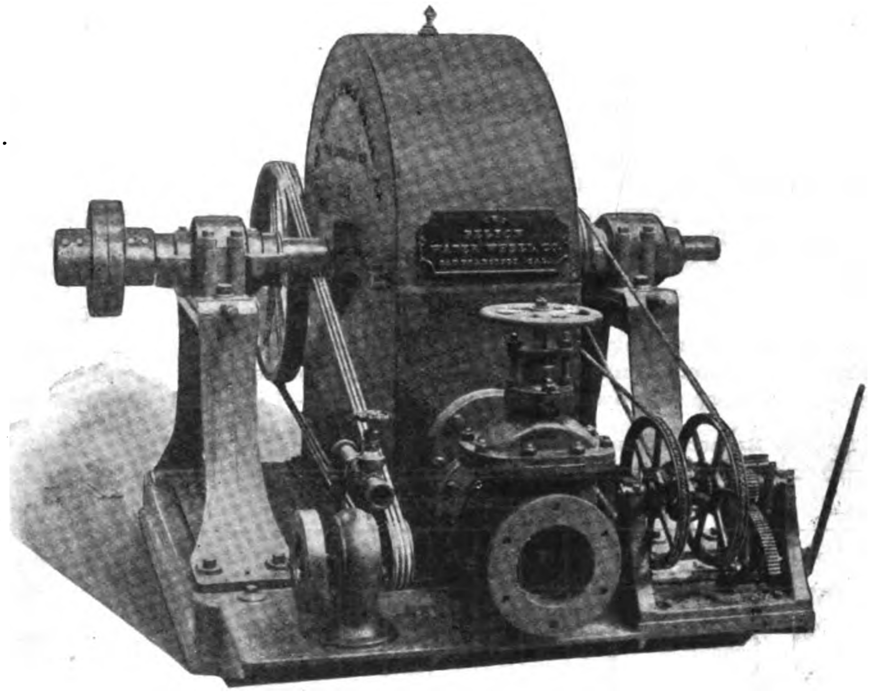


FIG. 9.—PELTON WATERWHEEL, NEVADA COUNTY (CAL.) PLANT.

The several views in Fig. 1 will enable an idea to be formed of the character of the country where the plant is installed, and the accompanying map (Fig. 10) shows the location of the power house of the two towns in the mining district, and the course of the main transmission line.

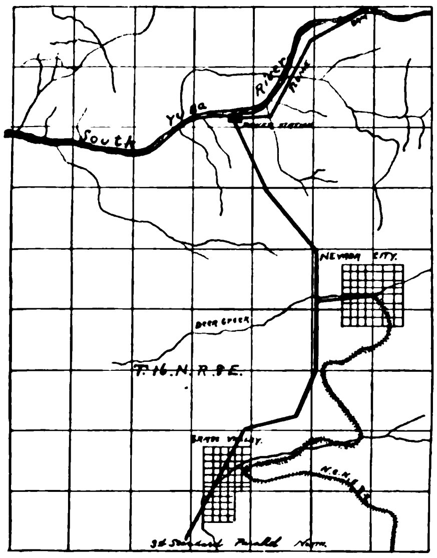


FIG. 10.

◆

Ornamental Arc Lamps.

In the article under the above caption in the June issue the name of Messrs. Oxley & Enos was inadvertently omitted from those to whom acknowledgment was made for the use of designs of ornamental lamps for reproduction to illustrate the article.

THE SELECTION OF A DYNAMO.

BY CECIL P. POOLE.

So many factors enter into the performance of a dynamo-electric machine that an attempt to do full justice to each detail of the subject of this article would soon expand into a treatise on dynamo construction; therefore, only the more important features will be considered.

Insulation.—The chief of all requirements is good insulation, and any sacrifice in this particular worse than nullifies a resultant gain in efficiency, weight, cost, or other items. An arc-light dynamo of the open-coil type should show an insulation resistance between commutator and shaft of certainly not less than five megohms, and this is also true of alternators; railway generators should test up very nearly as well—say, three megohms—and low potential machines ought not to show less than a megohm, the test in each case to be made with current at 100 volts or thereabouts.

Armature Windings.—To avoid overheating and carbonization of insulation, the armature of an arc-light dynamo of the Gramme ring bipolar type should be wound with No. 15 or larger wire (B. & S. gauge) for 9.6 amperes, No. 16 for 8 amperes, No. 17 for 7¼ amperes and No. 18 for 6.8 amperes; of course the armature surface, speed and total resistance define the heating effect mathematically, current being fixed, but as the armature surfaces and speeds of most Gramme ring arc machines of a given size are nearly identical, the size of the wire constitutes an indication which purchasers might well note. Concerning alternator windings suggestions are hardly necessary, as the disreputable types of this class of machinery have come to a natural extinction. This is also true to a great extent of railway generators; there yet remain, however, a few machines containing surface-wound armatures which it is a good plan to avoid. Low potential armature windings have also been brought to a state generally that leaves little to be desired. Nests of cross connections in the back ends of commutators, however, still furnish work for the repair shops and assist in elevating the temperature in the vicinity of some machines as well as the temper of their attendants. A drum armature is preferable the coils of which are individually insulated and the heads left uncovered; if the location in which the machine is to be used is particularly dusty and dirty, better enclose the whole machine in a closet large enough to allow a man to walk around it, than to have canvas heads put on the armature. If the dynamo is for central station service there is no excuse for allowing dirt or deleterious substances to accumulate in the armature heads. Select a machine, if possible, having the coil ends laid across the armature heads with some space between the individual coils and considerable between the inner and outer crossings; this will allow the dislodgment of any foreign substance that may creep in, without jabbing the insulation or wedging the coils out of shape. If a machine having a Gramme ring armature is preferred, care should be taken to avoid connections between coils and commutator that are soldered to the winding so close to the armature as to render repairs difficult in case of a break at that point. The joint should be fully an inch from the edge of the armature. For small machines separate connectors are objectionable; the ends of each coil should go to the commutator. It is almost superfluous to recommend slot-wound armatures as being generally preferable.

Commutator.—The commutator of a Gramme ring bipolar arc lighter should contain not less than four segments per lamp capacity, and five is a more desirable number. Constant potential machines should not be accepted having fewer than six segments per 100 volts, multiplied by the number of pole pieces; that is, a 500-volt machine with four poles should not have less than 120 segments in its commutator; eight times the number of pole pieces for each 100 volts is safer and gives much smaller tendency to sparking. The area of contact between the connections and the commutator lugs should be not less than ten times the cross-sectional area of the wire; otherwise there is danger of melting the solder out. The brush surface, if copper brushes are used, ought to be not less than one square inch per 100 amperes; with carbon brushes, four to six square inches, according to the E. M. F. of the machine, 500 volts E. M. F. requiring, of course, smaller brush surface per 100 amperes than 250 volts.

Brushes and Holders.—The brushes should be so arranged as to facilitate their removal or individual adjustment while the machine is running, and this without liability of mechanical accident to the attendant. This applies to alternators and arc-light machines as well as the less dangerous ones, as it is sometimes necessary to make these adjustments while a machine is running at full speed, though the field be "killed" and the machine be out of service. Carbon brush holders which clamp the brush firmly and move with it toward the commutator are preferable to the common slot and finger nuisance, which has nothing to recommend it beyond cheapness.

Field Magnet.—It is obviously impossible to point out any particular type of magnet as superior to all others. Whatever the type, it should be readily separable in large machines so as to permit the removal of the armature without dismantling the whole machine and disturbing all the electrical connections. In machines of twenty-five kilowatts capacity or less, the armature should be easily removable endwise by taking off one bearing—preferably the one at the pulley end. The magnet frame, if the machine be not of the iron-clad type, should shield the ends of the field coils farthest from the armature, or have lugs cast or bolted on for that purpose; the ends nearest the armature should be protected by heavy fibre or thin brass heads. The heaviest part of the magnet frame should lie below the armature, and if the magnet is symmetrical in weight all around the armature a very substantial base should be cast or permanently bolted on. The longest dimension of the machine, exclusive of base, viewed from the side or the end, should invariably be a horizontal one. The portions of the frame which support the pedestals or journal yokes should rest *directly* upon the sub-base.

TABLE OF MINIMUM PULLEY DIMENSIONS.

WIDTH OF BELT.															DIAMETER OF PULLEY.													
4	4½	5	5½	6	7	8	9	10	11	12	13	14	15	16	8	9	10	12	14	15	16	18	20	22	24	27	30	36
1000	875	750	665	600	500	438	375	335	300						10	11	12½	15	17½	18½	20							
1100	940	825	730	660	550	470	410	365	330						11	12½	14	17	19	20½	22							
1200	1050	900	800	720	600	525	450	400	360	300	Revolutions per minute of dynamo.				12	13½	15	18	21	22½	24	27		Horse-Power required to drive Dynamo.				
1300	1140	975	870	780	650	570	485	435	390	325					13	14	16	19½	23	24½	26	29	32					
1400	1225	1050	930	840	700	610	525	465	420	350	305				14	15	17½	21	24½	26	28	31	35					
1500	1310	1125	1000	900	750	655	560	500	450	375	330				15	16½	18¾	22½	26	28	30	33⅓	37½	40				
1600	1370	1200	1070	960	800	685	600	535	480	400	345	300			16	18	20	24	28	30	32	36	40	44	48			
1700	1460	1275	1130	1020	850	730	635	565	510	425	365	320			17	19	21	25½	30	32	34	38	42	47	51	57		
1800	1545	1350	1200	1080	900	770	675	600	540	450	385	340	300		18	20	22½	27	32	34	36	40	45	50	54	60	70	
2000	1750	1500	1335	1200	1000	875	750	665	600	500	435	375	335	300	20	22	25	30	35	37	40	45	50	55	60	67	75	90
		1690	1500	1350	1125	1050	845	750	675	560	525	425	375	335	310	25	28	33	38	42	45	50	56	62	66	75	85	100
			1665	1500	1250	1090	940	830	750	625	545	470	415	375	340	28	31	37½	44	46	50	56	63	69	75	85	92	112
				1800	1500	1310	1125	1000	900	750	655	560	500	450	410	375	38	45	52	56	60	67	75	82	90	100	112	135
					1600	1370	1200	1070	960	800	685	600	535	480	435	400	360	48	56	60	64	72	80	88	96	108	120	145
					1750	1500	1310	1165	1050	875	750	655	580	525	480	437	405	52	60	65	70	78	87	95	104	117	130	155
					1875	1600	1405	1240	1120	935	800	700	620	560	510	467	430	56	65	70	75	84	93	104	112	126	135	168
						1710	1500	1335	1200	1000	855	750	665	600	585	500	460	60	68	75	80	90	100	110	120	135	150	180
							1690	1500	1350	1120	965	845	750	675	615	560	520	485	77	85	90	100	112	125	135	150	170	200
							1875	1665	1500	1200	1070	940	830	750	680	600	580	535	85	90	100	110	125	132	150	165	180	220
								1730	1560	1300	1115	975	865	780	710	650	600	555	520	97	105	117	130	143	157	175	195	235
									1680	1400	1200	1050	935	860	760	700	645	600	560		112	126	140	154	168	190	210	250
									1800	1500	1285	1125	1000	900	820	750	690	645	600		120	135	150	165	180	202	225	270
										1625	1400	1220	1085	1025	885	810	750	700	650		130	146	163	178	195	220	245	290
										1750	1500	1310	1165	1050	960	875	805	750	700		140	157	175	190	210	235	262	315
											1715	1500	1335	1200	1170	1000	925	860	800		160	180	200	220	240	270	300	360
												1690	1500	1350	1230	1125	1040	965	900		180	200	225	250	270	300	337	400
				6	7	8	9	10	11	12	13	14	15	16	18	20	22	24	26		16	18	20	22	24	27	30	36
															WIDTH OF BELT.						DIAMETER OF PULLEY.							

Sub-Base.—It is essential to the convenient operation of belt-driven machines that the form of sub-base used should enable the attendant to tighten or slacken the belt by handling a single lever or wheel; the writer has seen a sixteen-inch belt wrecked by setting up one side of a double-screw base ahead of the other side, the attendant being unable to set up the slack side quickly enough to prevent the belt from running off. This, of course, was carelessness on the dynamo tender's part, but machines should not embody features that provoke or render practicable such carelessness. The mechanical connections between dynamo and sliding base should be such that the machine can be removed and replaced without the trouble of jacking up the base to the handle nuts, or sticking one's hand through an inch and a half crack for that purpose. The cheap form of base consisting of two tracks made in separate pieces is a vile makeshift that should not be countenanced under any circumstances; the base should be in one piece, substantial and rather massive, and should conform to the floor plan of the machine. The sliding surfaces should be directly under the bearings, and if the plan of the machine has the general shape of a cross, a sliding surface should also run under the center of the dynamo. Unless these points are observed the machine will run with more or less tremor.

Bearings.—The bearings should, of course, be self-oiling, and unless the yoke or pedestal has a circular seat, bored at the same time with the pole pieces, they should be self-aligning. The length of the journal brass should never be less than four times its bore, and boxes longer than five inches should be provided with a plurality of oil rings, chains or other oiling devices.

Pulley.—The most commonplace piece in the entire make-up of a dynamo, and one furnishing unlimited opportunities for petty annoyances, and some which are more serious, is the pulley. Unless it affords ample surface, a sudden pull, such as railway generators must withstand, results in belt slipping and deterioration, and it is frequently the case that machines running under full load require constant attention to avoid belt trouble.

The accompanying table will be found convenient for determining the minimum practical pulley dimensions. The table is used as follows: Assume a dynamo requiring fifty horse power to drive it, and designed to run at 850 r. p. m. Suppose the engine pulley and speed compel the use of a dynamo pulley twenty inches in diameter, required the least width of pulley face. Find the pulley diameter, 20, in the top row of figures, right hand section of the table; follow down this column until the horse power, 50, is reached; then follow that horizontal row over into the left hand section of the table until the number nearest the speed, 850, is reached; this is 875; follow up or down the column in which this number is and the minimum allowable width of belt, eight inches, will be found in either of the horizontal rows of figures at the top and bottom of the left hand section of the table.

If the conditions fix the width of belt—which is very rarely the case—the operation may be reversed to ascertain the minimum diameter of the pulley. When the exact horse power or number of revolutions does not appear in the table it is best to take the next *higher* number of horse power and the next *lower* number of revolutions, unless these are very much farther out of the way than the next lower and higher numbers. For example, if a dynamo has a twenty-inch pulley and requires sixty-five horse power to drive it, the figure 63 in the table would be preferable to the next higher number, 75; similarly, if such a machine ran at 810 revolutions, it would be nearer accuracy to take the number 830, which gives a ten-inch belt, than to take the next lower number, 750.

General.—High-speed machines should be avoided if possible; while they cost less originally than machines designed to run at moderate speeds, they deteriorate more rapidly, and render direct belting from the engine more inconvenient, not to mention their greater liability to run hot. Four thousand feet per minute should be regarded as the limit of belt speed; for economical belt operation 3000 is a good average speed. As the belt speed is determined by the diameter of the pulley and the number of revolutions per minute, this should be considered also in fixing the size of pulley, unless the dynamo is bought to be driven by an engine already on hand, in which case the engine pulley and speed will govern the diameter of the dynamo pulley, the speed of the latter being already fixed by the manufacturer. Superfluous ornamentation in the way of gilt stripes, flowery designs in gaudy colors, etc., are exceedingly undesirable. When new the dynamo has the cheap appearance of agricultural machinery, and when the ornamentation wears from necessary cleaning, it gives the machine a demoralized, junk-shop appearance.

Finally, no type of machine should be selected without witnessing its performance in actual service, if possible, or under conditions similar to those found in practice, during which performance the fields and journals should not even approach an uncomfortable heat, and after which the armature should not be too hot to allow the palm of the hand to rest on any part of it without serious inconvenience to the owner of the hand. The action of the oil in the bearings should be noted; if the machine throws oil outside the bearings, don't buy it.

HOW IS MOTION GIVEN TO THE ARMATURE OF A DIRECT CURRENT MOTOR?

BY TOWNSEND WOLCOTT.

The question has repeatedly been asked, 'Is it the attraction between the field magnets and the iron core of a motor that gives rise to the useful torque, or is it the attraction between the field and the armature conductors, or between the field and the current in the armature conductors?"

In motors having toothed armatures the torque is largely due to the first named cause. Strange as it may seem, the second hypothesis is the correct one in some motors, and has some effect in all motors. Although the copper conductors on the armature are not attracted by the field magnets when there is no current in them, and although when there is a current the attraction or torque is (with constant field) strictly proportional to the current, yet it is not the current itself which is attracted, but the conductor carrying the current.

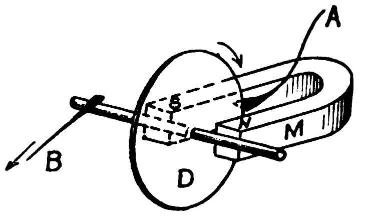


FIG. 1.

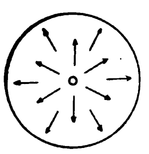


FIG. 2.

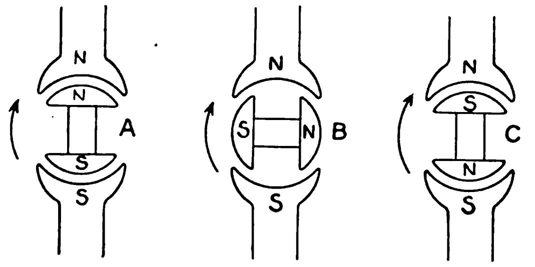


FIG. 3.

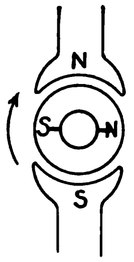


FIG. 4.

Among the early discoveries in electromagnetism was that a disk of copper placed between the poles of a magnet in the position shown in Fig. 1 and traversed by an electric current as there indicated (*A* and *B* being sliding contacts, *A* + and *B* —), would revolve in the direction indicated by the arrow. This device is here noticed, because it exhibits in its most elemental form the fundamental principle of one type of electric motors, and is, therefore, the proper starting point from which to build up the theory of the operation of any of the practical types of motors such as are in every-day use, in all of which there is some torque due to this cause.

To make the fact still plainer before entering into particulars, let Fig. 2 represent a copper disk, and suppose the current to enter at the center and to be taken off equally at all points of the circumference, so that the distribution of current is perfectly uniform in radial directions, as shown by the arrows. Then suppose there is a south magnetic pole beneath the paper and a north pole above, which produce a perfectly uniform field of force over the whole of the disk. This only differs from Fig. 1 in that the current distribution and magnetic field are uniform all over the disk. The disk revolves clockwise, or in the same direction as the disk in Fig. 1.

Here we have a perfect motor, torque, counter E. M. F. and all, but in which there is no attraction or repulsion of anything in the ordinary sense of the words. In ordinary language we only use the word attraction for a force which draws bodies together, and repulsion for a force which drives them apart. In Fig. 2 neither the disk as a whole nor any separate part of it approaches or recedes from the poles or vibrates between them, so that the turning force or torque is neither an attraction nor a repulsion, properly speaking.

The next question is, On what is this torque exerted, on the current in the disk or on the disk itself? The answer has already been given—on the disk. If we had a loaded boat floating gunwale deep in the water, and a dispute should arrise as to whether it was the weight of the cargo or that of the boat itself which caused it to sink so far, the dispute might be easily settled beyond all doubt by knocking the bottom out of the boat. If the cargo sank to the bottom and the boat floated higher than before, we would say it was the weight of the cargo (that is the pull of gravity on it) that made the boat float deep in the water. If, on the other hand, the boat should sink to the bottom and the cargo should float high in the water, we would say that it was beyond all question the weight of the boat itself and not that of the cargo that made it float deep.

Now in the case of any of the commercial forms of motors, the copper conductor of the armature is divided by insulation into separate channels, and it is not easy to say, *a priori*, whether the torque acts upon the current or the conductors which carry the current; that is, the cargo or the boat. Some have argued that the current tended to revolve and carried the conductors with it; that is, the cargo was the heavy part. But in the case of Fig. 2, we have the bottomless boat and behold, the boat sinks and the cargo floats, the disk revolves and the current does not. We have no direct proof that the current does not revolve, because whether it does or not it will still leave the periphery equally at all points, but in Fig. 1, where there is only one peripheral contact, it is evident that the current cannot revolve with the disk, and there is nothing in Fig. 2 to indicate that it does revolve there.

In the wire-wound armature a wire is caused by the torque to first approach a field pole, and then recede from it, so that the words attraction and repulsion apply to some extent, but are not really necessary, nor are they strictly accurate. For the force really tends to drive the conductors across the field so that they cut the lines of induction, just as in Fig. 2, and it is only incidentally that they are caused to approach or recede from a pole. When a conductor is under a pole there is no tendency for it to move radially either to or from the pole, but only tangentially or across the face of the pole. But whether we call the torque attraction or not, the force acts upon the conductor and the conductor carries the current with it, and not the contrary, as some have claimed.

Now as to the action of iron as a torque producer. Of course, the iron of the armature has an indirect action in producing torque, in that it serves as a path for the magnetic induction to travel, from pole to pole of the field, through the course which allows the lines to be cut in the most advantageous manner. But of direct attraction between field and armature iron in the same sense that a horseshoe magnet attracts its keeper, there has been a difference of opinion among authorities, but at the present time the opinion seems to be growing, that this direct attraction is the chief source of torque in toothed armatures, whether it be or not in smooth cored armatures. Wherever there is direct attraction of masses of iron in the armature, which are drawn to the poles, and then after commutation of the current are repelled, there are fluctuations introduced into the field magnetism and consequently into the current also.

In Figs. 1 and 2 is represented one extreme, where there is absolutely no attraction of anything, and where the currrent is absolutely uniform. Fig. 3 illustrates the opposite extreme. It is a motor with the oldest form of Siemens armature, known as the shuttle type. Starting with the armature in the position indicated at *A*, we will suppose that commutation has just taken place. The current then circulates about the two fields in one direction, and about the armature core in the other direction. If we consider the field current as acting on the field only and the armature current as acting on the armature only, we have the polarities indicated at *A* (Fig. 3), where two north poles come together and also two south poles, so that we have repulsion. If we consider the magnetic circuit as a whole, then the armature current in this position introduces a counter magneto-motive force. The armature then passes to the position *B* (Fig. 3), where there is both attraction and repulsion, and then to the position *C*, where a north and a south pole come into juxtaposition.

In this position the armature current evidently assists the field current in magnetizing the whole magnetic circuit and the total flux is therefore greater than in position *A*; but the moment after position *C* is reached, commutation takes place, the condition of affairs in *A* is re-established, and the cycle is complete. Or, in other words, after the magnetic flux has reached a maximum, it is suddenly reduced to a lower value (not necessarily a minimum, however, for in position *B*, the magnetic circuit is nearly ruptured), and this variation takes place periodically twice for each revolution of the armature. If any of the older forms of motors, in which, as in Fig. 3, there is genuine attraction and repulsion of the armature, be thoroughly investigated, it will be found that as in Fig. 3, there are periodic variations in the field flux commensurate with the attraction.

Now the question arises, How much if any torque or mechanical push or pull of any kind is exerted on the winding of such a shuttle type armature? In position *B*, Fig. 3, there is a chance for some of the lines of induction to cut the winding directly in passing from pole to pole, and in this case a corresponding mechanical force would be exerted. The amount of this stray induction as it may be called, is less as in proportion the groove or slot in which the winding is placed is narrower, and where as in modern toothed armatures the slots are narrow and deep with plenty of iron between them, there is very little stray induction. But whether or not there is stray induction in position *B*, there is practically none that can affect the winding in positions *A* and *C*. In these positions commutation takes place as before stated, and a large counter E. M. F. is set up in the winding, but whether in consequence there is necessarily any mechanical force exerted on the winding seems at present not quite settled, although there probably is not.

In the very early days of electric motors when the conservation of energy was not as well understood as at present and the function of the counter E. M. F. in a motor had not even been guessed at, motors were designed purposely to obtain the largest possible ferric attractions, in which object the designs were successful; much, however, to the surprise and chagrin of the designers, these motors would not do any more work than other motors in which the ferric attractions were less.

The reason for this is now thoroughly understood. The energy delivered by a motor must eventually come from the energy of the electric current with which the motor is fed, and this energy can only be converted into mechanical work in proportion to the counter E. M. F. generated in the motor. Now the only torque that is of any value is the mean value for a whole revolution or cycle, and the same may be said of the counter E. M. F. A ferric attraction may introduce a large torque at a particular point, but when the attracted mass has come as near as possible to the attracting pole, it becomes necessary, in order to continue the torque, to commutate the current in that portion of the armature. Then comes the day of reckoning, and squaring of accounts. The torque is paid for in form of a violent jerk in the counter E. M. F. due to commutating the current. A definite amount of work delivered per revolution of the armature (with constant speed), means a definite average torque, which in turn means a definite average counter E. M. F., and this depends on a definite number of lines of force cut by the armature conductors per revolution, and upon nothing else whatever. When there are ferric attractions, however great the torque may be at certain points, the mean value will be no greater than with the same magnetic induction through the armature, but without the attraction.

A common way of explaining the action of a motor is shown in Fig. 4. This is a modern armature, either drum or ring, and the polarities are the same as in *B* (Fig. 3). Now it is said that the north field pole attracts the south armature pole, and repels the north armature pole, while the south field pole attracts the north armature pole, and repels the south armature pole, and all these forces tending in one direction of rotation, the armature turns that way. If the brushes always made contact with the same commutator bars while the armature revolved this might be true, and the armature would turn until the north and south poles of the armature were respectively opposite the south and north poles of the field, when it would stop. This however, is not the case, for as soon as the armature has turned a very little another commutator bar comes under each brush and the armature poles are not greatly shifted in position, but vibrate back and forth over the width of one commutator bar.

Admitting this slight fluctuation of the armature poles, it follows that a part of the torque even in a smooth cored armature is due to ferric attraction, but this part is probably very small, and experience proves that nearly all the strain is on the conductors direct, for there is a strong tendency of the conductors to slide upon the core.

In conclusion it may be said that there are two distinct actions tending to produce torque. First, the direct action of a magnetic field on a conductor carrying a current tending to move it across the lines of magnetic induction, but not to attract or repel it. Second, the magnetic attraction and repulsion between the field poles and parts of the armature core, which attractions and repulsions, although due to the currents in the armature conductors, do not necessarily involve any mechanical strain on the conductors, though under certain circumstances they may do so.

Both of these actions may and do exist in the same motor, but in motors having smooth armature cores, the first is the principal one, the second being of no practical importance, while in motors having toothed armature cores, the reverse is the case. That is, the direct attraction of the teeth by the field poles is the chief source of torque.

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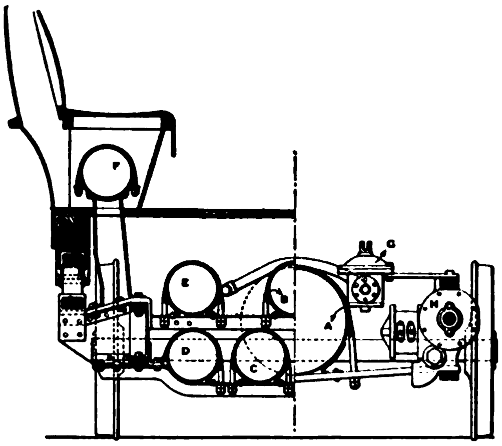
COMPRESSED AIR MOTORS FOR STREET RAILWAYS.

Two systems of compressed air street railway traction have recently been announced as rivals of electric traction. One of these is known as the Hardie system, and an experimental car employing it has been in operation for some time at Rome, N. Y. The other is the Hoadley system, and a number of experimental street cars are now being equipped with it for trial by the New York Metropolitan Street Railway Company. The New York Third Avenue Street Railway Company will similarly make a trial of the Hardie system.

None of those interested in either company will give any specific information in regard to the details of the systems. In both cases, however, the claims for radical superiority are based upon the use of air at a pressure of 2000 lbs. per square inch, which is stated to be four times greater than pressures heretofore employed. The Mekarski compressed air system, which is now used on several European street railways, uses a pressure of but 500 lbs. The weight of the car is given as 18,000 lbs.

The Hardie car at Rome contains in all sixteen air reservoirs, weighing 4340 lbs., and having a total capacity of fifty-one cubic feet. The left hand portion of the accompanying illustration shows the general arrangement of five of these. Those under the seats on each side run the entire length of the twenty-eight foot car; the others are supported on a framework of locomotive construction, as shown. A cylindrical tank (shown in the middle of the illustration) is half-filled with hot water at a high temperature, through which the air passes in order to be heated before entering the cylinders. This hot water attachment, it may be remarked, is not used with the Hoadley system. As the air is at an initial pressure of 2000 lbs. in the reservoirs, and has to be reduced to a pressure of 150 lbs. upon entering the motor cylinders, it takes on a very low temperature when thus expanded, and is therefore passed through the hot water tank to be heated.



SECTION THROUGH CAR.

The motor is precisely like a steam engine. There are two independent cylinders, 7 ins. × 14 ins., one on each side of the car, as shown at *H*. The front and rear wheels of the car truck are connected by a parallel rod as on a locomotive. (This arrangement was used on the cars of the Eickemeyer Street railway system, but with disastrous results on account of the impossibility of keeping the bearings from cutting.) The valves are of the slide pattern, and a modified Stephenson link is used.

The tanks are filled at regular intervals at the power house, steam at the same time being led into the water of the heater, which is given an initial temperature of 300 degs. to 325 degs. F., the final temperature being from 100 degs. to 190 degs. The tank is seven feet long and eighteen inches in diameter, and is jacketed with non-conducting materials.

MODERN COMMUTATOR CONSTRUCTION.

In the early days of industrial electricity the commutator of a dynamo or motor received less consideration at the hands of the builder than almost any other part of the machine. The current transmitted was trifling, and the difference of potential between bars was so insignificant that it gave no trouble and consequently was not made a factor in the general design of a machine.

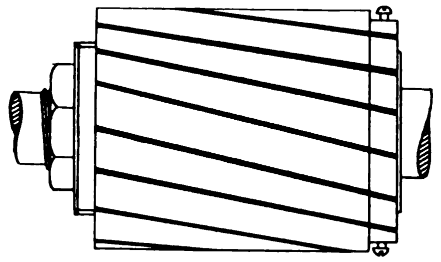


FIG. 1.

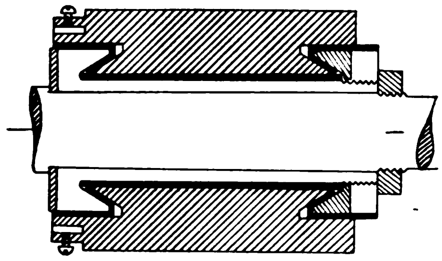


FIG. 2.

A commutator in those times was composed of a wooden cylinder with thin brass or copper strips attached by common wood screws; as the output of individual machines grew, this construction soon demonstrated its rank deficiencies, and a modification was made which consisted of strips a little thicker than before, with the ends next the armature turned outward radially and the opposite ends bent inward; an "ebonite" disk was put inside the outer ends, screws through the radial lugs holding the structure together at that end; a similar, but larger disk, was screwed to the outside of the radial lugs at the other end, and the builders of large machines (of five to ten kilowatts capacity) considered the commutator question forever settled.

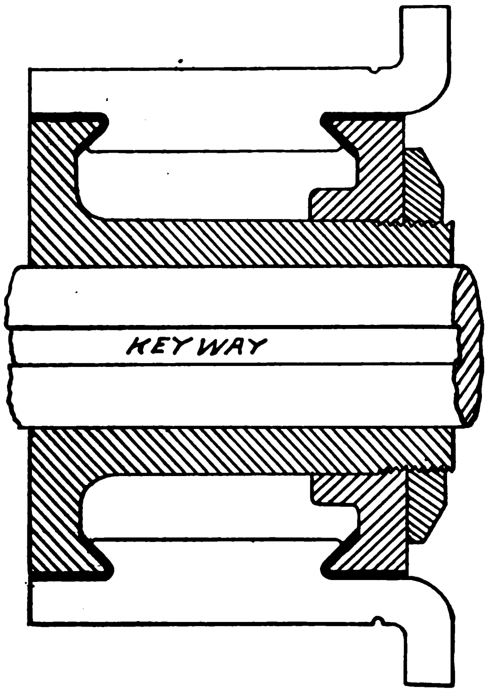


FIG. 3.

Within five years after the first machine was built for commercial service, however, many changes had been made and the essential mechanical features of the present commutator had been adopted as superior to everything else. Pasteboard, varnished linen, baked wood, and vulcanized fibre were tried in rapid succession for insulating the segments, each proving immediately its inadequacy, so that to-day a commutator insulated with anything short of the best quality of mica is not deemed worth freight charges.

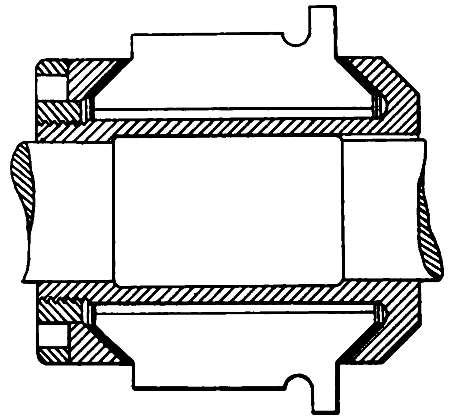


FIG. 4.

It is interesting to note the variety of ideas embodied in modern commutator construction. While the general plan is the same in all, the details of construction are almost numberless. Fig. 1 shows the form of commutator built by the Stucky & Heck Manufacturing Company for old style Weston arc-light dynamos. It reminds one at the first glance of the original strip commutator above referred to, but inspection of the sectional view given by Fig. 2 shows that the only similarity is in the twist given the segments. The bars are of the inside-bevel type; the sleeve and one end ring are in one piece; the clamping ring is forced into place by an annular nut screwed on the end of the sleeve. This is the earliest type of the bevel-ring commutator, and one upon which it has been difficult to improve, so far as the structure of the commutator itself is concerned. The connecting wires are held by binding screws in holes drilled parallel with the shaft and in the ends of the segments. A sleeve of mica is placed on the metal sleeve of the shell to guard against contact between the latter and the inner edges of the bars. The beveled surfaces and the overhang of the segments are insulated from the shell by one-piece rings of mica or micanite, pressed into shape.

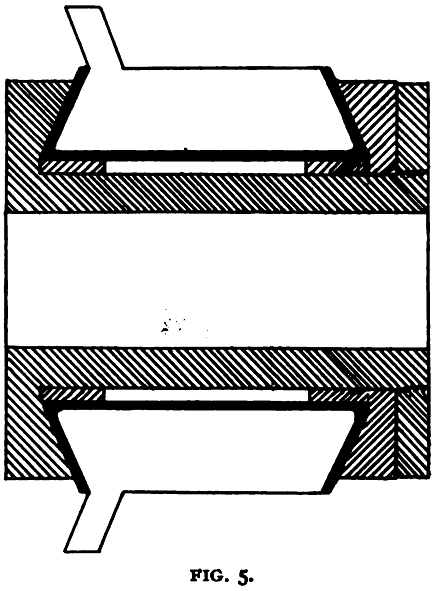


FIG. 5.

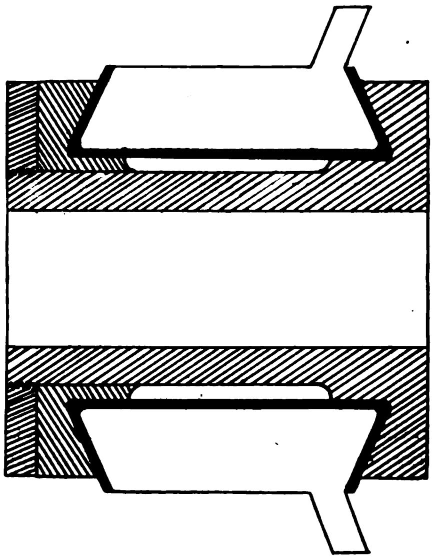


FIG. 6.

A commutator of the same type is that of the Elektron Manufacturing Company, shown by Fig. 3; the only differences in form are greater clearance between sleeve and segments, and the addition of radial lugs slotted to receive the armature leads. The mica insulating rings are $\frac{3}{32}$ in. thick; no mica sleeve is required because of the greater clearance mentioned, and the clamping collar has a short hub to stiffen it. The frame or shell is made of cast iron. The bars are drop-forgings, and the insulation is pure mica between bars and shell and also between the bars themselves. The copper segments and mica segments are set up carefully in a jig, which is then placed in a lathe and the taper grooves at each end are accurately turned out. The mica insulating rings and the shell are then put in place and are locked by the heavy nuts shown in the drawing at the right hand end. The two parts of the shell are forced together under great pressure and then locked by the nut. The mica insulation is allowed to project at the end toward the armature, also at the inside edges of the bars. At the outside end the shell, the insulating rings and the bars are flush with each other and are turned off smooth so that

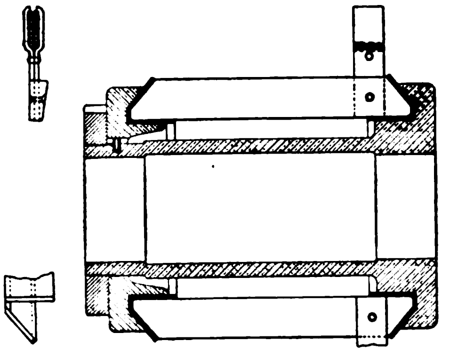


FIG. 7.

it is impossible for any dust or dirt to lodge and start short circuits.

Fig. 4 shows the commutator of the Storey Motor & Tool Company, which is similar to the two just described. The segments are of the outside-bevel type, with the brush surface extended radially beyond the bevel.

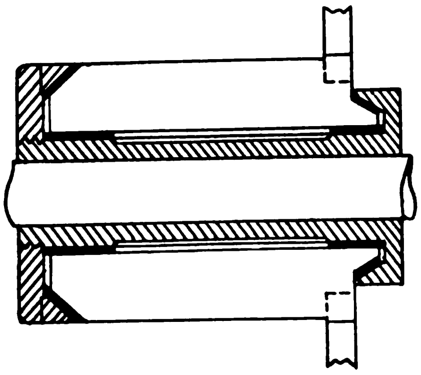


FIG. 8.

In this commutator, the annular nut has the same external diameter as the clamping collar, obviating any tendency to buckle or dish the latter. A very similar segment is used by the Royal Electric Company, as shown in Figs. 5 and 6. The bevel extends, however, clear up to the brush surface, and an insulating bushing is slipped inside the cylinder formed by the segments. The commutator, shown by Fig. 5, differs from its mate (Fig. 6) in having separate metal rings to give the ends of the bars an internal bearing; these are displaced in the other commutator by a shoulder on the sleeve and a hub on the clamping collar.

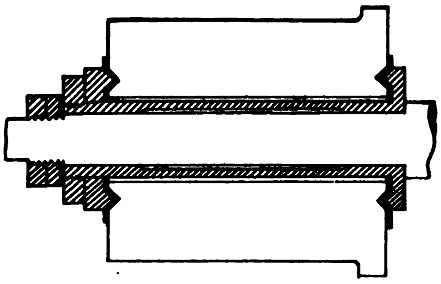


FIG. 9.

The commutator used by the Fort Wayne Electric Corporation on bipolar machines, shown by Fig. 7, is almost exactly like that in Fig. 6; the tightening collar, however, is provided with a pin inserted radially in the inner edge; this pin projects into a slot in the sleeve and prevents the collar from turning when the nut is set up. The connecting lug is formed of two strips of copper riveted together and to the end of the segment, as shown in the upper left hand corner of Fig. 7; the outer ends are bent so as to form a clamp for the ends of the wires coming from the armature. The insulation at each end of the segments is formed of three separate mica rings, one cylindrical, one discoidal and one conical; the conical ring laps the discoidal one, so as to keep out deleterious substances and press the two rings tightly together; the sketch in the lower left hand corner of Fig 7 shows this.

Fig. 8 shows a commutator used by Paterson & Cooper in England. It is very similar to the Storey commutator (Fig. 4); the connecting lugs are separate from the segments, soldered to them; the end insulation is like that of the Fort Wayne commutator, minus the discoidal rings.

The Gülcher Company, in Germany, uses a commutator bar with a double internal bevel, as shown in Fig. 9. The tightening collar and the back flange each has a beveled ridge corresponding with the groove formed by the nicks in the ends of the bars when assembled, and four mica rings are used at each end for insulation, two discoidal and two conical. The shell is held on the shaft by being pressed against a shoulder at the back end by a nut against the front end, which is secured by a jam nut.

The commutators built for Weston and United States machines by the Stucky & Heck Manufacturing Company are almost identical with the Gülcher device; the clamping collar, however, has an internally projecting pin, like that used in the Wood commutator, (Fig. 7,) and the following nut, after being set up hard, is prevented from backing off by a small screw passing through it into the clamping collar. This commutator is shown by Fig. 10. The Gülcher commutator (Fig. 9) has a greater proportion of reserve metal for brush wear than the Stucky & Heck; otherwise the bars are identical.

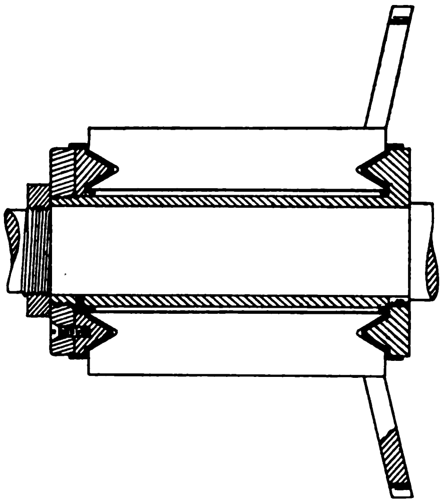


FIG. 10.

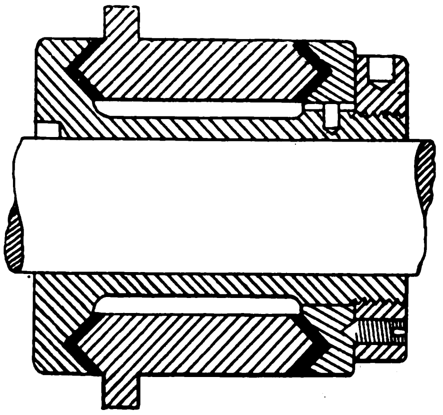


FIG. 11.

A segment having a double *external* bevel —the reverse of the two just described—is used by the E. G. Bernard Company; the relative arrangement of sleeve, clamping collar and nut is like that shown in Fig. 10. The sleeve is kept from turning on the shaft by a pin driven in the shaft and fitting into a radial slot in the back end of the sleeve. The following nut is not screwed to the clamping collar after being set up, as in the Stucky & Heck arrangement, a very fine thread being used in the nut; the Bernard commutator is shown by Fig. 11.

A rather peculiar commutator segment of the internal-bevel type is used by Kapp in some of his machines built in England. As shown in Fig. 12, the bars have a very narrow nick in each end, one side of which is axially straight and the other slightly beveled, placing it in the class with internal-bevel bars, though there is no overhang to speak of. Another feature peculiar to this design is a hub extension of the nut, on which the clamping collar is fitted, the object of this arrangement being to avoid any liability to spoil the threads on the sleeve by forcing the clamping collar over them; a compensating disadvantage entailed by this construction is an increased tendency to twist the collar in setting up the nut, and thereby twist the commutator segments out of parallelism with the shaft.

A very simple commutator made by Stuckey & Heck for electro-plating machines is shown by Fig. 13; it is for a six-pole machine with a single coil on the armature—a very small machine—and is composed of two disks, or heads, each having three fingers extending parallel with the shaft and equidistant around the circumference of the disk. Each disk has a hole in the center, bushed with mica, and the two are slipped on the shaft with the fingers intermeshing, electrical contact between the fingers of opposite disks being prevented by mica strips, as between ordinary commutator segments. The disks are forced together by a nut on the shaft, which also secures them to the shaft itself; a shoulder on the shaft behind the commutator holds it against the pressure of the nut.

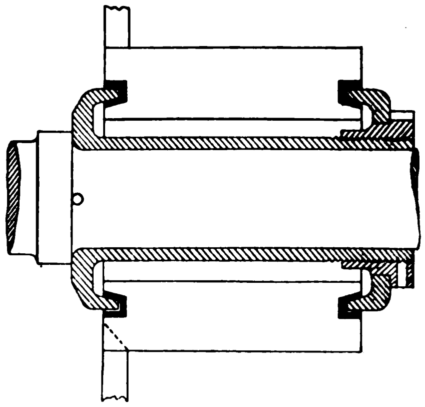


FIG. 12.

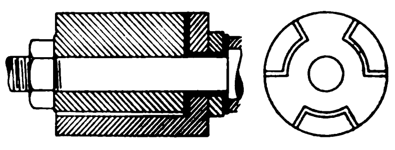


FIG. 13.

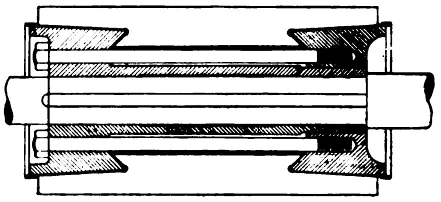


FIG. 14.

Fig. 14 shows a method of clamping used on some of the General Electric Company's medium-sized commutators. Instead of forcing the beveled clamping collar in place by means of a nut, it is pulled home by bolts which pass through the head of the shell and tap into the collar. The overhang of the commutator bar flares slightly, and the face of the head and that of the collar are tapered to fit the flare, mica rings being interposed to prevent cross-circuiting. The collar is splined on the sleeve to obviate a possible twisting movement, and the sleeve is keyed to the shaft.

Another form of bolted commutator is that of the Triumph Electric Company, shown by Fig. 15. In this case, however, the diameter of the commutator is so large that the bolts do not need to go the full length of the shell, but pass through the clamping ring and tap into the near side of the shell. Internally-beveled segments are used, insulated on the inner face bevels and under the overhangs by pure mica without shellac.

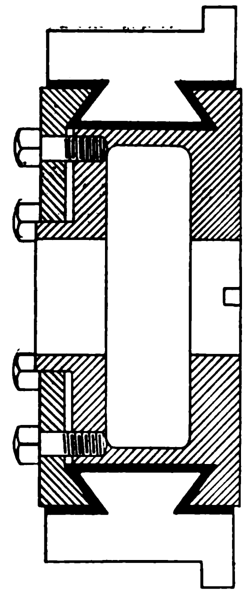


FIG. 15.

A still different form of bolted construction is used by the Siemens & Halske Electric Company, of America, and shown by Fig. 16. This commutator is also provided with segments which are removable individually and without disturbing the armature connections. Permanent segments of brass, indicated by the shaded portion of the drawing, are provided for receiving the connecting wires from the armature; removable copper segments, beveled externally, are seated on the brass segments and held in place by beveled blocks faced with mica strips and bolted to the shell by cap screws set radially. The brass segments are beveled externally at the back end and insulated underneath and on the bevel in the usual manner; the pressure of the beveled blocks on the front bevel of the copper segments holds both in place. The shell is secured to the shaft by keys, and prevented from sliding by the long set-screw near the extreme right hand end in the sketch.

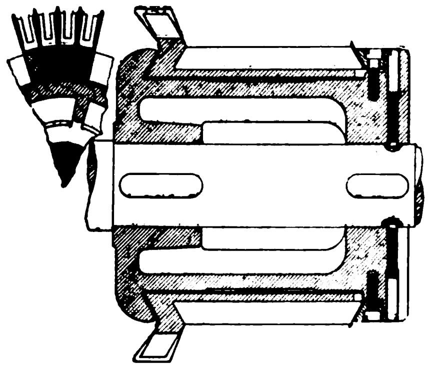


FIG. 16.

With the advent of multipolar generators direct connected to the engines came armatures of large diameter and many coils, necessitating commutators of correspondingly large diameter and many segments. The sleeve form of shell, which is unexcelled for moderate diameters, was mechanically clumsy and was speedily superseded by the spider frame, now universally used. A commutator of that kind is shown by Fig. 17; it consists simply of the old sleeve-and-head shell, enlarged in diameter and cast in one piece with radial arms extending inwardly to a hub keyed to the shaft, forming a sort of pulley with a beveled flange on one edge. The clamping collar becomes a ring and is drawn on by bolts, as in the case of the commutator shown by Fig. 14, except that the bolts pass through the clamping ring and tap into the head or flange of the shell. Internally-beveled segments of hard-drawn copper are used; the insulation is of solid mica. Strip connectors are used between the segments and the armature conductors. This construction is used by the Walker Company on large direct-connected railway generators.

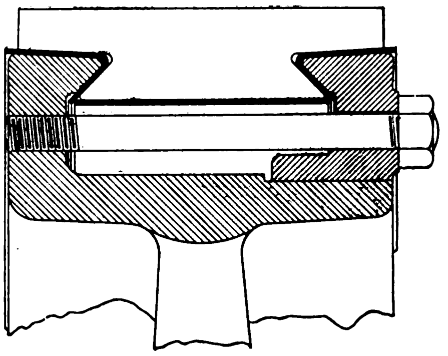


FIG. 17.

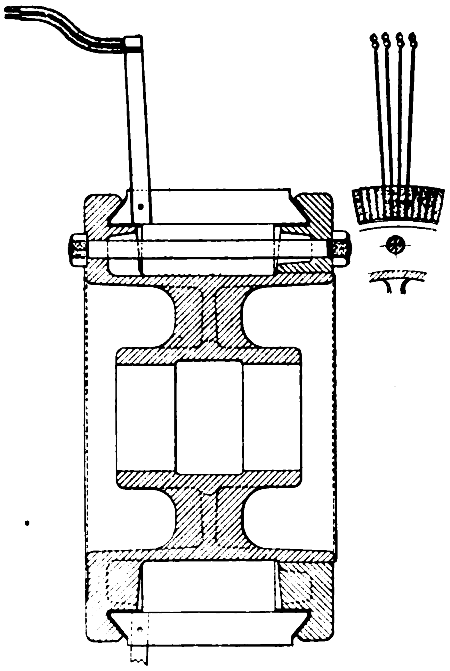


FIG. 18.

An almost identical construction is one employed by the Ft. Wayne Electric Corporation, shown by Fig. 18. The only mechanical difference is in the use of tie rods with a nut at each end, instead of bolts tapped into the shell, to draw up the clamping ring. The segments are beveled externally and have radial connecting strips riveted on, the bar being grooved on the side to receive the strip. The detail in the corner of the drawing shows the method of attaching the wires. This commutator is used on the Wood arc-light dynamos of sixty lights and upward, excepting the 125-lighter.

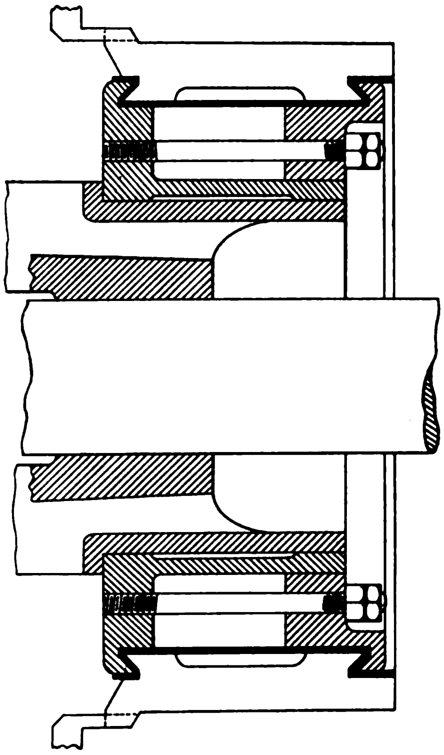


FIG. 19.

A somewhat similar arrangement is the General Electric Company's commutator shown by Fig. 19. Instead of casting a flange on one edge of the spider, however, clamping blocks are used at each end of the segment; these blocks are curved to conform to the circumference of the commutator, and when in position form virtually two clamping rings similar to those commonly used. Dividing the clamping rings into segments permits one section of the commutator surface to be renewed or re-insulated without disturbing the remainder of the bars, which is of great importance when the number of segments runs up into the hundreds.

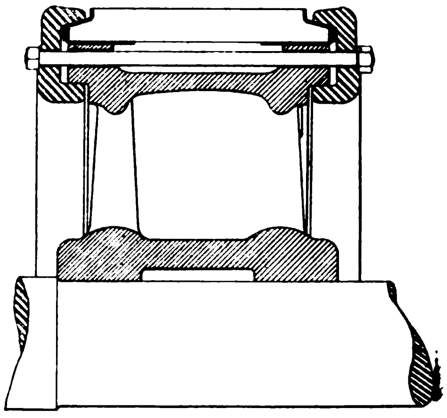


FIG. 20.

Fig 20 shows the Thompson-Ryan method of mounting a commutator. A cylindrical extension of the armature spider serves to carry the shell, which is of the familiar sleeve-and-head type, much enlarged as to diameters. The clamping collar is unusually heavy axially between the segment and the sleeve, and is secured in place by nuts on studs which are permanently set into the back head and protrude through holes in the clamping collar; a jam nut is added. The segment is of the internal-bevel type, insulated on the bottom, bevel and overhang. Strip connectors lead from the armature to the commutator.

The commutator of the 125-light Wood arc machine is shown by Fig. 21. It is mounted on a hub projecting from the armature spider in a manner somewhat similar to that employed by the builders of the Thompson-Ryan dynamo. The clamping ring is secured in place by means of tie rods passing through the ring and the head, with a nut on each end. The segment is hollowed out on the surface, between the brush surface and the point where the connecting strip is riveted on, and beveled externally. The armature wires are attached to the outer ends of the connecting strips by means of screws.

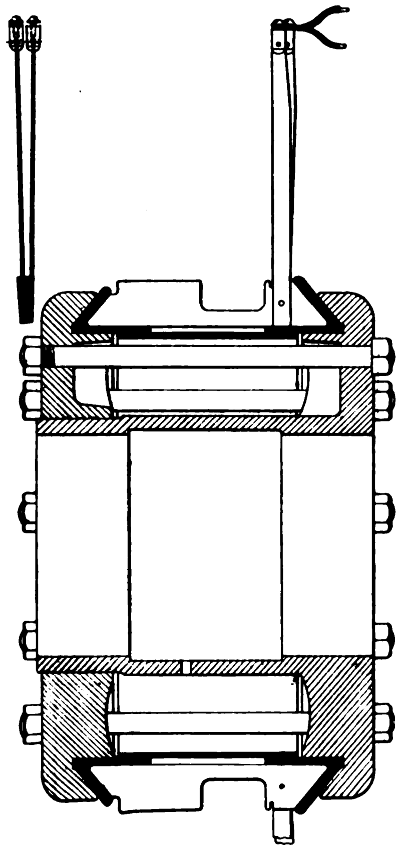


FIG. 21.

Out of the beaten track entirely is the radial commutator used on some direct-connected lighting generators of the General Electric Company. One of the rings that clamp the armature disks together is machined so as to leave a lip corresponding to the beveled head of the ordinary shell; the segments are of the internal-bevel type with unusually long overhang. They are drawn together radially by curved clamping blocks bolted to the armature check plate by cap screws, as shown in Fig. 22. The segments taper from end to end instead of edge to edge. As in the case of the General Electric railway generator commutator (Fig. 19), part of the segments may be removed without disturbing the rest. No connectors are used; the armature coils have one turn each, and the ends go directly to the commutator segments.

The designs shown by the accompanying cuts include all types of commutators in extensive use to-day; there are a few eccentric forms in use here and there to a limited extent, but modern practice does not recognize any essential variations from those here illustrated. All makers use copper of the best quality, drop-forged, hard-drawn or tempered (so-called); the shells are made sometimes of brass, but generally of iron; the insulation used by reliable makers is invariably mica in one form or another. The method of making connection between segments and armature winding still remains a bugbear and is the subject of a vast deal of thought and experiment.

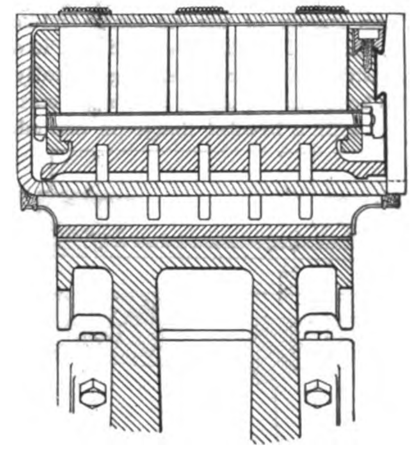


FIG. 22.

◆

Electrical Copper and Silver Refining.

One of the largest single shipments of electrical apparatus ever made was recently sent by the Westinghouse Electric & Manufacturing Company to Great Falls, Mont. The shipment filled eight freight cars, and the freight of the cargo to its destination amounts to $8000. The machinery will be used by the Boston & Montana Consolidated Copper & Silver Mining Company in the refining of copper and silver, and is the largest machinery of its kind ever constructed for electrical refining purposes. The Boston & Montana Company is one of the largest copper mining concerns in the Northwest.

Until a few years ago the copper produced in that country was not refined, but the copper matt was sent East, some of it to England, and there refined. Since the introduction of electricity into the refining process, the companies are in a position to compete with the East. The Anaconda Mining Company purchased from Westinghouse some time ago seven 360-HP generators, of an output of 3600 amperes each at seventy-five volts. Since those machines have been in operation the electrical process of refining has proved a great success. The machinery of the Boston Company will be driven by turbines from the waters of Great Falls.

The generators will be directly connected to turbines, of which there are two, the largest ever made, each one being of 1100 HP, at an output of 4500 amperes and 180 volts. These machines are shipped in four freight cars, while the other four are filled with the detail apparatus, such as switchboard appliances, etc.

RÖNTGEN RAY TUBES.

BY ELIHU THOMSON.

I have read the article entitled "A Röntgen Ray Outfit—II" in the AMERICAN ELECTRICIAN for June, and also the article by Mr. Herbert B. Shallenberger in the same issue, and find that there are a few statements in the former article which I might criticise. Thus, in the second paragraph, in referring to the thickness of the glass of the Crookes tube, it is stated that thick glass used in Crookes tubes heats to a very high temperature, and that if the tube is forced it frequently gets red-hot under the influence of the discharge. I think this statement, made without qualification, is not exact, as it is a fact that Crookes tubes made of thick glass, if the glass is not bombarded by the cathode rays, are not particularly different in temperature from those made of thin glass. The statement probably applies only to those parts of the glass of the Crookes tube which are bombarded by cathode rays, and which, when thick, retain and distribute the heat, and, of course, thick glass in all cases is more apt to crack by changes of temperature than thin glass.

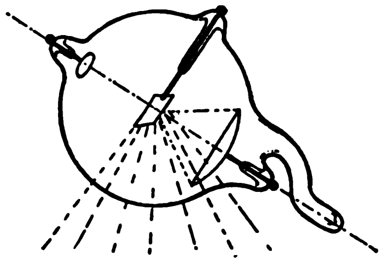


FIG. 1.

At the present time it is not necessary to make a statement in regard to the fluorescence of the glass as having anything to do with the evolution of Röntgen rays, since it is now well known that the glass of the tube when not bombarded by the cathode rays has only the effect of acting as a more or less transparent shield or absorbent for Röntgen rays; and that lead glass is more absorbent than crown, or what is known as German glass. Further, substances which do not fluoresce are efficient sources of rays.

The statements in the third paragraph with regard to the size of the tube being an important feature are, I think, at this time out of date, as it is known that sharpness of detail is not dependent on the size of the tube, but rather on the size of the spot which is bombarded and which becomes the source of the rays. The statements as to the size of the tube in relation to detail are evidently based on the mistaken notion that the whole glass of the tube is the source of the rays. If the bombarded spot in the tube is very small, whether the tube itself be

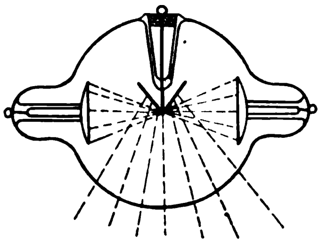


FIG. 2.

large or small, the delineation obtained will be sharp. I must take exception, also, to the statements in regard to the so-called "perfect vacuum tubes." With such tubes it is almost impossible to produce a discharge if the exhaustion is as thorough as indicated, and if Röntgen rays are produced from such tubes it is because they are imperfect "perfect vacuum tubes." It is not at all true that a tube which has the property of forcing discharges to pass over its exterior has also the property of generating Röntgen rays. Neither does it follow that because the tube has such a perfect vacuum, or is a small tube, that the Röntgen shadows will be sharp, as that depends entirely on the extent of bombarded surface; that is, the total size of the spot emitting the Röntgen rays.

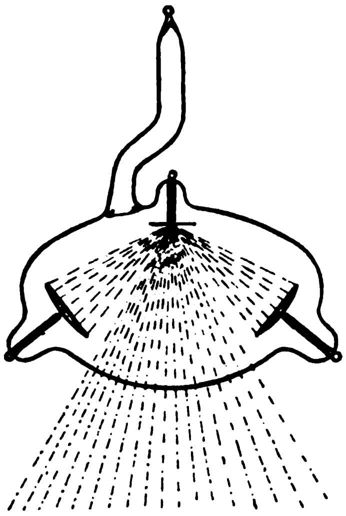


FIG. 3.

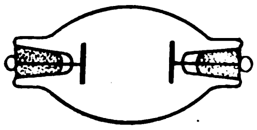


FIG. 4.

I notice that in speaking of the work of Mr. Herbert Shallenberger, in the fifth paragraph, he is credited with a perfection of work which owes its success to the use of Crookes tubes of the type of Fig. 1. I would say that in my own experience the first Crookes tube which I employed was exactly like the tube, Fig. 1, and the first Röntgen pictures obtained were as sharp as any that I have seen since. The work with this tube was begun by me immediately after the publication of Professor Röntgen's discovery, and I have no doubt that others have used similar tubes with equally good results, but have said little about it.

It is a surprise to me that some experimenters still adhere to the use of tubes in which the glass itself is bombarded and in which the glass becomes the source of Röntgen rays. It is, therefore, a surprise to me that tubes such as are exhibited in Figs. 4, 5 and 6 are used at all now, in view of the fact that it is known that platinum is so much more active than glass, and that by properly shaping the cathodes the focusing of the rays is a comparatively simple thing to attain.

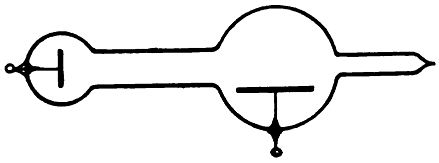


FIG. 5.

In regard to the forms of tube, Figs. 2 and 3, I would say that the form, Fig. 3, which has been proposed by Mr. A. A. C. Swinton was suggested by me before I had arrived at the form, Fig. 2. I had directed that form 3 be made, but at once realized the difficulty, and almost impossibility, of getting the two cathode foci to coincide on the bombarded platinum, since the cathodes are brought into the bulb at angles, and it would depend entirely on the judgment of the glass blower whether their foci were coincident, or whether they covered the same spot on the bombarded platinum anode. I, therefore, soon discarded the arrangement of Fig. 3, and adopted the arrangement, Fig. 2, a description of which was published some time ago, because it was more simple to make as a glass-blowing operation, the cathodes were more easily brought to proper position, because they faced each other and were in line, and the distance of the cathode terminals could be made as great as desired. I think that, as a matter of fact, the forms of tube which are likely to survive are tubes that are substantially like Fig. 1 or Fig. 7, and such tubes as Fig. 2, which may be called universal tubes because they are capable of being used with any character of source of electric discharge giving the requisite potential.

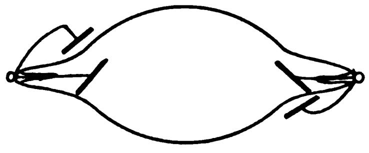


FIG. 6.

I entirely agree with Mr. Shallenberger that the form of tube, Fig. 1, which was the first form with which I worked, is an excellent form of single focus tube, particularly if the platinum be made the anode, but, of course, it is not adaptable to the use of alternating discharges such as are obtained with high frequency apparatus.

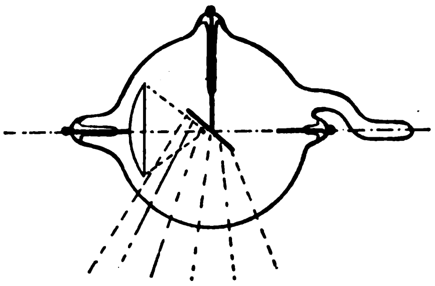


FIG. 7.

* * *

The Kelvin.

A higher official of the British Board of Trade in referring at a recent meeting of an electrical association to the name "Board of Trade Unit," stated that it was to have been called the *Kelvin*. Lord Kelvin objected, however, for the reason that he was soon to put a wattmeter on the market and therefore the use of his name would not be advisable. Why not call the unit by its real name—kilowatt-hour—as in this country?

CANADIAN ELECTRCIAL ASSOCIATION.

The sixth annual convention of the Canadian Electrical Association, held at Toronto, Ont., June 17, 18 and 19, was a successful one notwithstanding a somewhat smaller attendance than usual. Mr. John Gule, of Guelph, was elected president for the ensuing year, Mr. L. B. Macfarlane, of Montreal, first vice-president and Mr. Carl Breithaupt, of Berlin, second vice-president. Mr. C. H. Mortimer, editor of the *Canadian Electrical News*, was re-elected secretary.

The inevitable paper on "Acetylene Gas" was on the programme, Mr. Chas. Black being the author. The familiar chemical equations and partial estimates of cost offered as total cost, with electrical energy figured at lower rates than it can be purchased at Niagara in quantities of thousands of horse power, of course, appear. The discussion brought out the fact that the author of the paper is interested commercially in acetylene gas, and the opinion was expressed in discussion of the paper that the figures given were entirely too optimistic.

In a paper on "Power Transmission by Polyphased E. M. Fs.," Mr. Geo. White-Frazer sketched the principles of polyphased currents and apparatus. The subject of loss in lines is considered and shown to be entirely dependent on commercial considerations. If there is a demand for power at a high figure and the source of power is limited, the line loss should be small; if, on the other hand, the supply is large and the demand limited or the price low, it may be best to choose a large line loss, in order to reduce the copper outlay. In addition, in the latter case motors should be chosen having the best efficiency at average load rather than at maximum load.

A paper by Mr. Jas. Milne describes various forms of electric light meters, but its main object seems to be the defense of the Edison electrolytic meter, which appears to have been practically condemned by the Canadian Government. The following advantages are advanced for the Edison meter:

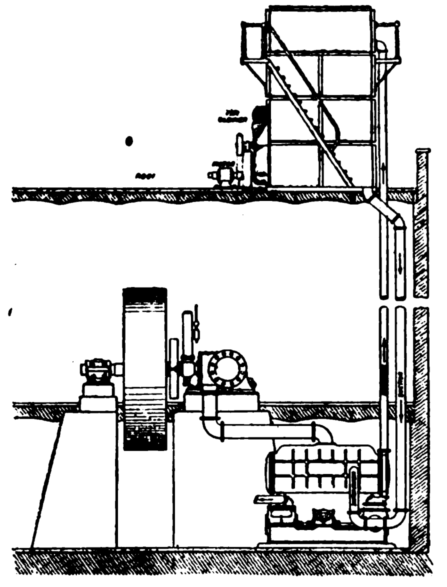
1. Practically no loss; 2. No moving parts; 3. Absolutely correct at all loads; 4. Will record the smallest possible amount of current; 5. It is applicable to any pressure; 6. Low first cost; 7. Low cost of maintenance; 8. Readily repaired. "The only disadvantage (if any) is that the consumer can't read it for himself."

On the other hand, motor meters are allowed only one advantage—that the consumer can read them—and the following disadvantages are enumerated:

1. Loss in overcoming friction in the moving parts; 2. Incorrect at light loads; 3. Incorrect at quickly varying loads; 4. First cost high; 5. Cost of maintenance high; 6. Not readily repaired.

The conclusion of the author is that as a practical meter the Edison chemical type is superior to all others in every point except one—that the consumer cannot read it.

A paper on "Operating Engines Without a Natural Supply of Condensing Water, or the Continuous Use of Injection Water," by Mr. E. J. Philip, described the Barnard tower water-cooling system, illustrated herewith. The tower is filled with wire netting rolled up loosely and set on end. At the bottom is a settling chamber; above this is a heavy grating, under which the fan discharges the air for cooling; on the grating are placed the wire rolls, which are continued up as far as the material will support itself, breaking joint so as to break up the streams of water. The sides of the tower extend above the filling of wire netting in order to allow the particles of water to settle out of the air current, thus preventing spray from flying from the top, and also any water from being wasted. As will be seen, hot condensed water enters the top of the tank, where it is sprayed over the netting and cooled in its descent by a fan draught from the blower shown on the left. About fifty square feet of cooling surface is required per horse power or 4.8 cu. ft. of tower.



BARNARD WATER COOLING SYSTEM.

The most important paper read at the meeting was on "Some Central Station Economies" by P. G. Gossler, giving an account of the reconstruction of a large central station system. The location of the station is not named in the paper, but indications it conveys seem to point to a certain station in New York City. The enormous importance of the transformer question is dwelt upon; in the present case 187 old transformers replaced by new ones of high efficiency will entail a yearly saving in coal alone of $25.58 each, the average cost of the change, crediting the old transformers as scrap, being $65.00. When all of the old type of transformers have been replaced and groups of smaller ones replaced by a single large transformer, the saving in current will be equivalent to that used by 1000 16-CP incandescent lamps, 60,000 lamps now being served from the station. Much stress is laid upon the necessity of good regulation; it is stated that a daily rise in voltage of three to four per cent. will reduce the life of an incandescent lamp about one-half.

In a paper on "The Outlook for the Electric Railway," Mr. F. C. Armstrong made the prediction—without, however, giving any sufficient grounds—that present members of the Canadian Electrical Association will see electricity supersede the steam locomotive in the operation of the Canadian Pacific and Grand Trunk Railway systems.

LORD KELVIN.

Prof. Hospitalier in *L'Industrie Electrique* pays a tribute of admiration to Lord Kelvin upon the occasion of the Glasgow jubilee, held to celebrate the fiftieth year of his occupancy of the chair of Natural Philosophy at the University of Glasgow.

To few, it is remarked, is reserved "the honor of entering living into immortality," and among this small number there figures in the first rank the illustrious savant just fêted at Glasgow. All of the learned bodies of the entire world were represented during the celebration, in almost every instance one or more of their most illustrious members attending to render homage in person.

Born at Glasgow June 25, 1824, young Thomson, at the age of eleven years began his studies at the University of Glasgow, where his father, James Thomson, son of a Scotch-Irish tenant farmer, occupied the chair of Mathematics. He terminated his studies at St. Peter's College, Cambridge, and published his first paper on original mathematical research, at the age of eighteen. When twenty-two years old he was called to the chair of Natural Philosophy at the University of Glasgow, which he has ever since occupied, notwithstanding tempting offers made from time to time by other universities of Great Britain. The previous year the young scientist had spent in the laboratory of Regnault in France, where he doubtless acquired that facility for exact experimentation which has been one of the prominent characteristics of his work.

Pages would be required to simply enumerate the titles of Kelvin's scientific papers, and the scientific instruments and industrial apparatus, due to his inventive genius. As examples, three branches of applied science are chosen which owe most to him—submarine telegraphy, navigation and electrical measurements.

It can be said without exaggeration that submarine telegraphy is the entire work of Lord Kelvin. It was in 1855 that he presented his paper on the mathematical theory of the speed of transmission of signals through submarine cables to the Royal Society, and in 1857 Prof. Thomson invented the mirror galvanometer employed in laying the first Atlantic cable in 1859. A year after the laying of the 1866 cable, Sir William Thomson (knighted the same year) took out his first patent on the siphon recorder, which he perfected during the next three years. It is this instrument which is exclusively employed to-day in cable telegraphy, through short or long lines, and with or without the aid of a later automatic attachment, the "curb sender," which extends its speed.

The services rendered to navigation are not less important. To Lord Kelvin is due the complete theory of the variation of the compass and the means of correcting the same; a ship's compass which is in use to-day in all the warships and merchantmen of the world with the exception of U. S. Naval vessels; and marine sounders, both for sounding in shallow water and for deep sea work—without speaking of a large number of inventions less important, but not less useful.

The measuring instruments invented by Lord Kelvin are innumerable: the quadrant and absolute electrometer, industrial electrometers, electro-dynamometers, continuous and alternating current wattmeters—from instruments of the highest precision to simple indicators—and everywhere used throughout the world in scientific and industrial laboratories and electric generating stations.

The characteristic of the work of Lord Kelvin is that, always, theoretical speculations the most elevated or mathematical calculations the most abstract, have led to the production of apparatus of a marvelous simplicity, of which each has marked the beginning of an important industrial advance, sometimes even resulting in a direct human benefit.

Prof. Hospitalier, in conclusion, says that "Impartial history will always preserve remembrance of the scientific conquests of a Newton, of an Ampere, of a Faraday and of a Lord Kelvin, when the greatest conquests of war will have been forgotten. Aside from truth, all is vanity. Happy are those who pass their lives in seeking truth and succeed as has Lord Kelvin!"

LORD KELVIN.

During the jubilee ceremonies, which took place Tuesday, June 16, in giving thanks for the honors showered upon him, Lord Kelvin mentioned among others the students to whom he lectured at Johns Hopkins University, whom he called "My twenty Baltimore coefficients of 1884," and then continued as follows:

"The term coefficient is abused by mathematicians. They use it for one of the two factors of the result. To me the professor and his class of students are coefficient fellow-workers, each contributing to whatever can possibly be done by their daily meetings together. I dislike the term lecturer applied here. I prefer the French expression—"conference." I feel that every meeting of a professor with his students is rather a conference than a pumping in of doctrine from the professor, perhaps ill understood and not well received by his students. The Scottish universities have enabled us to carry out this French idea of conference. I think in every one of his classes the professor is accustomed to speak to his student, sometimes in the form of vivâ voce examination, and oftener, I hope, in the manner of interchange of thoughts, the professor discovering whether or not the student is following his lecture, and the student pointing out his own view on the subject, and helping the professor through his treatment of the subject. I have had addresses also from my old Japanese students of Glasgow University, now professors in the University of Tokio, or occupying posts in the Civil Service and Engineering Service of Japan. I wish particularly to thank my Baltimore coefficients for their address. They have been useful to myself in my own keen endeavor—unsuccessful, I must say—nevertheless keen—to find out something about—to know something about—light and ether and crystals. The addresses which I have received to-day contain liberal and friendly appreciation of all my published mathematical and physical papers, beginning in 1840, and ending—not yet, I hope. The small proportion of that long series of writings which has led to some definite advancement of science is amply credited for its results. The larger part, for which so much cannot be said, is treated with unfailing and sympathetic kindness as a record of persevering endeavor to see below the surface of matter. It has been carried on in the faith that the time is to come when much that is now dark in physical science shall be seen bright and clear, if not by ourselves, by our successors in the work. I am much gratified by the generous manner in which these addresses have referred to the practical applications of science in my work for submarine telegraphy; my contributions to the advancement of theoretical and practical knowledge of the tides; my improvements in the oldest and next oldest scientific aids to navigation, the sounding plummet and the mariner's compass, and my electric measuring instruments for scientific laboratories, for the observation of atmospheric electricity and for electrical engineering."

At a banquet later in the day Lord Kelvin referred to his life work as follows:

"When I think how infinitely little is all that I have done I cannot feel pride; I only see the great kindness of my scientific comrades, and of all my friends, in crediting me for so much. One word characterizes the most strenuous of the efforts for the advancement of science that I have made perseveringly during fifty-five years; that word is failure. I know no more of electric and magnetic force or of the relation between ether, electricity, and ponderable matter, or chemical affinity, than I knew and tried to teach to my students of natural philosophy fifty years ago in my first session as professor. Something of sadness must come of failure; but in the pursuit of science, inborn necessity to make the effort brings with it much of the *certaminis gaudia*, and saves the naturalist from being wholly miserable, perhaps, even allows him to be fairly happy, in his daily work. And what splendid compensations for philosophical failures we have had in the admirable discoveries by observation and experiment on the properties of matter, and in the exquisitely beneficent applications of science to the use of mankind with which these fifty years have so abounded! To live among friends is the primary essential of happiness; and that, my memory tells me, we inhabitants of the University have enjoyed since I first came to live in it in 1832, sixty-four years ago."

220-VOLT LAMPS.

Recently considerable attention has been given in Europe to the subject of 220-volt lamps, which have commenced to enter into some use there. At a meeting last month in England of an association composed of the electrical engineers of municipal plants, a paper by one of the members was read in which the various advantages and disadvantages of high voltage lamps were considered, and the conclusions arrived at, that the 220-volt lamp will soon be recognized as the most useful advance made in electric lighting for some time, that it is now on the market, has been tested and found satisfactory in several towns, and is here "to stay,"

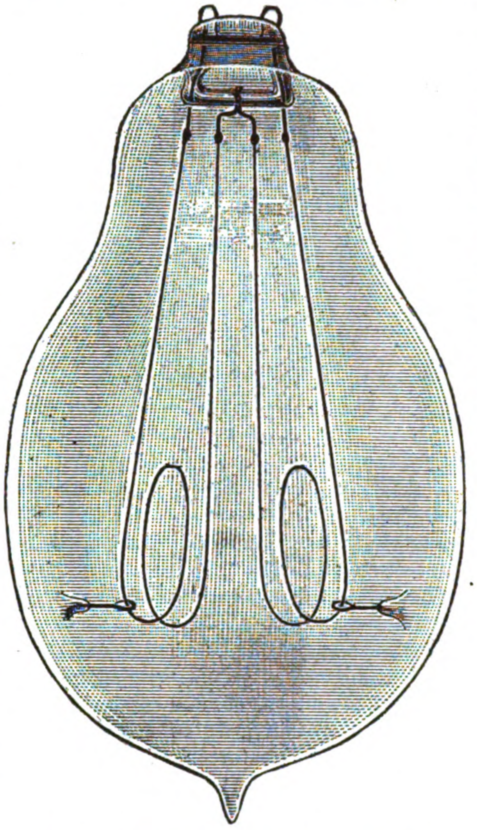


FIG. 1.—EDISON-SWAN 220-VOLT LAMP. (FULL SIZE).

Among the advantages pointed out are that with 220-volt lamps installed on existing mains can supply twice as many customers, at the same time reducing the drop and loss by one half; variations and fluctuations due to the switching on or off motors or large groups of lamps, or carelessness in switching dynamos in or out at the station, are correspondingly all reduced by at least one half; and new customers can be supplied at a much greater distance from the station.

Mr. Barnard, the author of the paper, states that the best 220-volt lamps now on the market take 3½ watts per candle power, or 40 per cent. more energy for the same amount of light than the most efficient 110-volt lamp now used, which takes 2½ watts. He adds, however, that while he has never heard a complaint from his customers in regard to 220-volt lamps, the contrary is the case with 2½ watt, 110-volt lamps, most stations, in fact, preferring to use 3 to 3½-watt lamps. Besides, there will be no difficulty in obtaining 2½ watt, 220-volt lamps in 16 and 32 CP, and, owing to the less fluctuation, they will be more reliable than the lamp of smaller voltage.

As to the extension of lighting territory made possible by the high-voltage lamps, Mr. Barnard believes that a district 2 miles square may be efficiently served from a station or sub-station. At Bradford a station being erected is designed to supply to a distance of 1½ miles over an area of 9 square miles, using the three-wire system and 230-volt lamps. A total area of 17 square miles will be supplied from the same station by means of dynamotors.

In answer to the question, How will the higher pressure affect the wiring and fittings on consumers' premises? Mr. Barnard thinks there is nothing to fear on the score of increased fire risk, the reduction in current, he believes, quite balancing the double voltage. With attention to the details of fittings, such as fuses, switches, cut-outs, etc., wiring at 220-volts will be just as cheap and rather safer than at half that pressure. Certain little American switches used by him at Hull, and which get perceptibly warm with a 32 CP, 110-volt lamp, will keep quite cool and work with less sparking on a 220-volt lamp of the same candle power.

Fuses appear to act more suddenly and certainly at 220 than at 110 volts. A badly soldered joint is far less likely to cause trouble under the new conditions, as the heating would be less and the loss of voltage at the joint also smaller proportionately. With the higher voltage, Mr. Barnard considers single pole fuses better than double pole ones, and that moisture condensed on fuse bases is more likely to cause leakage.

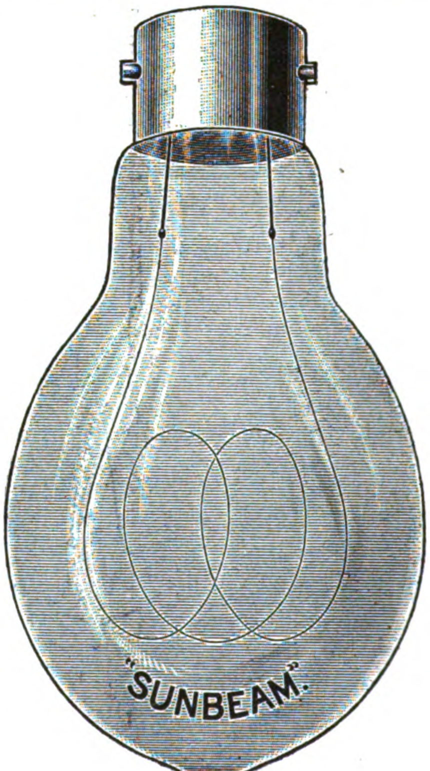


FIG. 2.—SUNBEAM 220-VOLT LAMP. (FULL SIZE).

The types of 220-volt lamps shown by the accompanying illustrations (which we reproduce from our English contemporary, *Lightning*), were all tested by Mr. Barnard. Some makers have brought out an ingenious fitting which enables 110-volt lamps to be used two in series on a 220-volt circuit. While Mr. Barnard thinks this a neat method of getting over some objections to 220-volt lamps, particularly with respect to 8-CP lamps, he considers it hardly adapted for universal use, as the two lamps will not go into many of the glass shades, etc., in use, and many people will consider that their appearance is not nearly so æsthetic as that of the single bulb. Other makers have put the two filaments into one bulb, and coupled them together, either inside the bulb or just outside the neck in the plaster cap. Several firms have, however, boldly grappled with the question, and have succeeded in making single-filament lamps having bulbs little or no larger than those commonly in use, and these seem to indicate the lamp that will shortly be commonly adopted.

As might naturally be expected, Mr. Barnard added, the lamps with single filaments have hardly reached the stage of durability and efficiency that the double-filament lamps have attained. For all that, however, most excellent results have been obtained from some individual lamps of this type, and equally poor results with samples of double-filament lamps. On this question Mr. Gibbings, the borough electrical engineer of Bradford—where double-filament lamps are mostly in use—wrote as follows: "The 230-volt lamps are very much appreciated by our consumers; in fact, we are continually being pressed by those we have not changed over to do so, and we find that the life of these lamps comes out, if anything, better than the ordinary 115-volt lamps." While Mr. Barnard considers that such favorable and positive testimony as this is rather surprising, the secret is to be found in the steadier and more even pressure supplied, rather than in the better quality of the lamps. In either case, it is most satisfactory and encouraging, and, he thinks, should help to convince any who doubt the possibility of a commercially good 220-volt lamp being made that, at any rate, it is quite possible to equal the results from the 110-volt lamp.

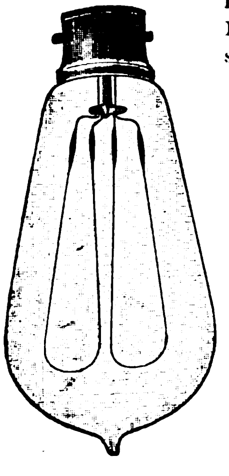


FIG. 3.—CRUTO 220-VOLT LAMP. (½ SIZE).

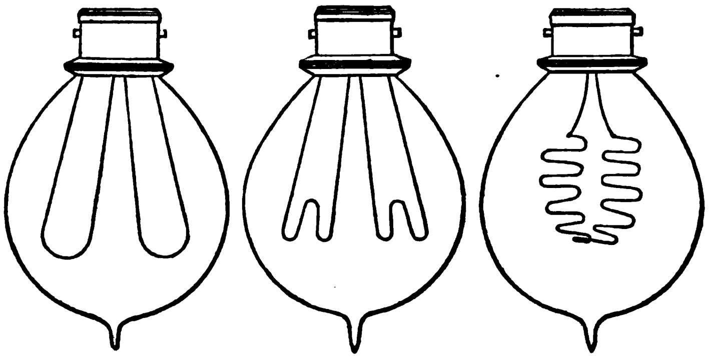


FIG. 4.—STEARN 220-VOLT LAMP. (½ SIZE).

In the lamps under Mr. Barnard's own observation, the average life is quite equal to that of the best makes of 110-volt lamps. With the exception of one maker's samples, the candle power has been maintained longer, and there has been less blackening of the glass. Several lamps fail through short circuits occurring in the cap, but this fault also is absent from the lamps of several makers. Other lamps have failed through the long filament touching the glass whilst hot, and so cracking it and admitting air; and especially has this been the case when these lamps have been run in any position other than vertical.

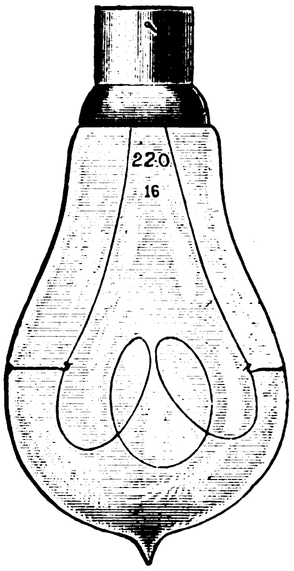


FIG. 5.—FULLER 220-VOLT LAMP. (½ SIZE).

In the discussion which followed the conclusion of the paper, the engineer of the Manchester plant stated that it was not a question of what was *going* to happen with the higher voltage, because in Manchester they had had it in practical operation, and with no trouble whatever. He pointed out that the statement as to the old fittings being equally suitable to the higher voltage is a fallacy, and exhibited some specimens showing the brass and copper run together in one mass and the porcelain smashed in every case.

The representative of an incandescent lamp company stated that if the filaments were perfectly made, 8-CP 200-volt lamps would have as long a life as 100-volt lamps. Naturally, however, if the size of the filament is decreased, it must have mechanical support.

The engineer of the Bradford plant stated that he had 385 consumers using high-voltage lamps and they never made any complaints.

NOTES.

Political Candidates in Electrical Affairs.—Hon. Garret A. Hobart, Republican nominee for vice-president, has taken much interest in electrical affairs, and is now president of Paterson (N. J.) Electric Railway Company and a director of the Paterson Edison Illuminating Company. Comptroller Roberts, of New York State, a prominent candidate for the New York governorship, is also largely interested in electrical enterprises.

Spectro-Photometry.—Our enterprising contemporary, the *Progressive Age*, is interesting the gas industry in the study of spectro-photometry, or the analysis of light to determine the relative extent in which the several colors of the spectrum enter. In order to further this object, a set of apparatus is furnished at a low price—$6.00—to those who will take up the subject. Perhaps some of the users of the Welsbach light may be disagreeably surprised at the indications of the spectro-photometer.

The Northwestern Electrical Association.—The summer meeting of the Northwestern Electrical Association will be held at Marinette, Wis., July 15, 16 and 17. Following is a list of the papers to be read, abstracts of which will appear in our August issue: "Rights of Electrical Companies," by W. Clyde Jones; "The Insurance of Electrical Plants," by R. H. Pierce; "Insurance," by C. C. Paige; "Alternating Current Motors," by Prof. D. C. Jackson; "Lightning Arresters," by W. R. Garton; "The New York Convention and Exposition," by T. R. Mercein.

A Great Engineer Honored.—Commodore George W. Melville, engineer-in-chief of the United States Navy, has received the degree of Doctor of Engineering from Stevens Institute. But once before in the history of Stevens Institute has this degree been conferred, Prof. R. H. Thurston, director of Libby College, Cornell University, having been the recipient of the honor some years ago. During Commodore Melville's administration of the Naval Bureau of Steam Engineering, he has directed the design of all of the machinery of the new navy, the success of which has placed the United States easily ahead of the rest of the world in marine engineering.

Automatischespiegelglassplattenblitzschutzvorrichtung.—The little device thus designated, says the *Electrical World*, and referred to quite innocently by a German contemporary, is, as its name clearly indicates (when read backwards), simply an apparatusforprotectingagainstlightningconsistingofplatesofmirrorglassactingautomatically, or as we would say more briefly in this country, where time is money, a form of "cut-out." It is to protect circuits against lightning, and although its name describes it in detail, the description is not full enough. A narrow strip of silvered glass is scratched on the the metal side with numerous transverse lines (called in German, Zwischenraumbreiten) their number depending on the voltage or the circuit. One end of this strip is connected to the line and the other to the earth. The atmospheric electricity will pass over the scratches, but the dynamo current will not follow. Although simple, cheap and effective, its name is a fatal objection in this country.

Still Room!—Our English contemporary, the *Electrical Review*, comments as follows on an accident to a Brooklyn trolley car some time ago: "We have seen it stated somewhere that there is always room for one more on a U. S. trolley car. That certainly seems to have been the case with a Brooklyn electric car a few weeks ago, for 132 passengers was not a sufficient load for the ambitious conductor. Perhaps he was trying his hand at record-breaking, for he admitted yet another, thus making a grand total of 133; and it is to be supposed that had not Providence intervened, he might have added further to it. But it was ordered otherwise, for this well-laden car ran backward down a hill for a third of a mile, killing a boy, fatally injuring a woman, seriously injuring six other passengers, and slightly injuring nearly two dozen others. It is not an uncommon occurrence for the police in this country to stop an overloaded car, make the standing passengers withdraw, and summons the conductor. Not so in America it seems. Oh, what a happy place is Brooklyn!"

College Publications.—The periodical literature of engineering courses at colleges has in recent years formed a valuable addition to the technical press. Owing to the policy of encouraging original research now prevailing in most engineering schools, the possession of well equipped laboratories, the absence of commercial hindrances, and the guidance of able instructors in experimental work, these publications have assumed a technical value of no mean order. As an example, the initial number of the *Wisconsin Engineer*, a goodly sized quarterly issued from the University of Wisconsin, contains fourteen articles on various engineering subjects, every one of which would repay reading by the practising engineer. Electrical engineering is represented by four articles—"Storage Batteries for Railway Power Stations" by W. H. Williams; "Subways for Electric Wires" by W. C. Burton; "Two Wattmeter Methods for Tri-phased Circuits" by B. D. Frankenfeld; and "A New Method of Measuring Current Variations in Telephone Transmitters" by Arthur H. Ford.

The New York Telephone Company.—A company was recently incorporated at Albany under the name of the New York Telephone Company, with a capital of $16,000,000, and has taken over the business of the Metropolitan Telephone Company, which serves New York, Brooklyn and vicinity. With the surplus capital, it is rumored, local telephone companies in New Jersey and perhaps that of Philadelphia will be absorbed. At present all of the territory in New York State within a radius of 33 miles from the New York City Hall—excepting Long Island and Staten Island—is included within the limits of the new company. As the contract with the Western Union Company, by the terms of which that and the Bell companies engaged not to enter the field of the other, expires in November, and as one of the Goulds is an incorporator of the new company, it is thought by some that this move presages a new arrangement. There would be a mutual advantage in a combination with respect to local telephone companies through avoiding duplication of offices, but the Long Distance Telephone Company will have a strong position in the telegraph field, as all of its wires can be used for telegraphic purposes without interfering with telephone transmission, and no new office expense will be entailed if advantage is taken of this upon the expiration of the contract referred to.

Engineering Education.—A writer in the *American Machinist* submits a table of the present occupations of 650 graduates of Worcester Polytechnic Institute, showing that while the larger number are actively engaged in lines of work for which the Institute specially prepared them, the more responsible positions were gained after years of service, to which the Institute training was merely the foundation, and in no way a part of the superstructure. It is added that no institution, however thorough or severe its course of instruction and training, can be supposed to turn out foremen, superintendents, or anything else. It simply turns loose a lot of raw material, from which later on, these various grades of engineers may develop. Opinion during recent years is becoming more and more inclined toward the correct view involved in this conclusion—that engineering schools cannot graduate engineers, but merely impart the knowledge and training which, in practical work, will assist in the development of the faculty of sound commercial and technical judgment—without which none is an engineer, however complete may be his knowledge of engineering principles and methods, or however well supplied he may be with engineering titles or affix initials to his name.

Kelvin and Fleeming Jenkin.—The late Prof. Fleeming Jenkin was associated with Lord Kelvin, then Sir William Thomson, in the work of perfecting the siphon recorder, and at one time the two Scotch professors were for some days housed together in the Land's End terminal station of the Atlantic Cable during the course of some experiments. Prof. Jenkin was then preparing his text book on electricity and magnetism—a work, which for many years remained a standard college treatise—and during the stay at the station the matter of the text was the subject of many discussions between the author and Sir William, which often assumed an animated character. At times when the sound of the gruff voice of Prof. Jenkin and the querulous tones of Sir William seemed to portend a more than usually obstinate stand by the former on some question, the superintendent of the station would enter their room and with a few joking words calm the disturbance, invariably due to the pugnacious Scotch obstinacy of the former in defending some statement of theory or fact written for the book. On these occasions Sir William, much irritated, would protest to the superintendent that Jenkin would give him credit for knowing nothing, that Jenkin considered himself infallible and all others ignoramuses, etc.—intellectual modesty not permitting any consciousness of his authoritative rank. A few moments later the difference of opinion would be forgotten and amicable relations resumed.

Lord Kelvin as a Practical Man and as a Reader.—In an address delivered before the San Francisco Academy of Sciences, Mr. W. F. C. Hasson contrasted the eminently practical qualities of mind of Lord Kelvin, with those of an another English savant. Professor Cayley in England writing to Professor Sylvester in America sent, as was his custom, his latest most intricate mathematical deduction. He closed his letter with the statement that he was not only pleased with the deduction, but was still further pleased by the fact that it could be put to no practical uses. Mr. Hasson adds that Sir William Thomson, as he will ever be known despite his later title, did not hold any such puerile opinion of the value of his mathematical intelligence. Another anecdote related referred to Lord Kelvin's visit to America in 1884. While at Johns Hopkins University, he asked permission to borrow a lately published book to which his attention had been called by one of the professors. Returning it the next day he said that he had found it extremely interesting and would like to procure a copy for his library. The book being one that had attracted much attention, the professor, in surprise, asked Sir William if he had not seen it before. In reply he said that his own work occupied him so thoroughly that he rarely found time to read. "It appears that he has not only learning, but that comprehensive knowledge that the Buddhist recluse vainly strives to attain by contemplation."

Tesla and Marriage.—Our sprightly contemporary, the *Electrical Journal*, takes issue with Mr. Nikola Tesla as to the undesirability of marriage for inventors, and after disproving his statement that few great inventions have been made by married men, proceeds as follows: "We are great admirers of Mr. Tesla and his work. We give him credit for mighty good hard sense. We do not think he is like the Frenchman who excused his bachelorhood on the ground that he was 'one butterfly, zat fly from ze flower to ze flower and sip ze honey.' We know, too, that Mr. Tesla's nature is a very intense one, but we have just faith enough in women—especially American women—to make Mr. Tesla a straight-out offer to find a girl for him who will not only match his intensity in all respects, but who will tax his inventive genius to the utmost—and hence encourage it—trying to explain where he was at 2 A. M. some night when she had gone to his laboratory to bring him home and found it dark, although he had told her he was going to have to 'stay down town to work to-night.' Then again, if Mr. Tesla were to have ordinary Benedict luck and half a score of little Teslas, his inventive genius would be kept up to a white heat, hustling for the wherewithal to supply their wants. Mr. Tesla knows that 'necessity is the mother of invention.' Fie, Mr. Tesla, fie, we say. Get married. You'll get strong, be happy, sleep o'nights; and if you leave an invention or two less to posterity, you will leave a more material and fully as necessary a legacy in another shape. Besides, they try to steal inventions from a man; they don't steal his children, seldom his wife, and never the pleasures that a married man falls heir to."

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Efficiency of Transformers.

In a paper read before the recent Canadian Electrical Association by Mr. P. G. Gossler, the great importance of the transformer question, particularly in connection with large plants, was illustrated by some startling figures. By replacing some old transformers by new ones of high efficiency, a saving in coal, alone, of over $25 per year was effected, the entire outlay for the new transformers through which this saving was made being but $65. In the case of the plant to which the paper refers, its capacity will be increased by 1000 lights without any additional current being required, when high efficiency transformers have displaced all of the less economical types—part of the gain, however, to come from "bunching" small individual transformers where this is practicable. In addition to the gain from the less current supplied, will be a further one due to less lamp renewals, while the smaller fluctuation in voltage will render the service much more satisfactory.

Commutators.

The reader will find much to interest him in the article printed elsewhere in this issue, on different forms of commutators, in which he will find illustrations of practically every type now used. While the improvements in commutators in recent years have been marked, the most notable advance has been in the attention paid to care in manufacture and in insulation. It is less than ten years ago that one manufacturer attempted to insulate a 500-volt commutator by coatings of insulating paint between the segments, and it is within a shorter period that wood and various composition insulations have been entirely abandoned in favor of mica, which has alone stood the test of time.

The commutator in its present form is perhaps the greatest of all electrical inventions, if we may so designate what has been a gradual development from the first two-part armature attachment, and being the vital part of the dynamo, has well deserved the attention which has been given it. It cannot yet, however, be said to have reached its final state, for at present there appears to be no consensus of opinion as to the best method of attachment of conductors to the lugs. Almost every maker has a different method, and judging from the constant changes, none seems sure that his is the best. Another desirable improvement, and one to which some attention is now being given, is a construction that will permit a defective bar to be removed and replaced without disturbing the commutator as a whole. One commutator of this kind is illustrated in the article.

Leakage Current.

Much confusion seems to exist concerning the real significance of "leakage current" as applied in connection with transformers, some apparently believing that it represents a leakage in the proper sense of that word. This, of course, is no more true than that the shunt current of a dynamo represents a real leakage, for, as in the case of a dynamo, a certain amount of current must pass in order to magnetize the iron—this magnetization in the case of a transformer on open circuit being necessary to "choke" the primary flow. The leakage current of a transformer, in fact, is made up of a number of components. Part, as above stated, is necessary to magnetize the iron circuit; another part is expended to overcome hysteresis or magnetic lag—the effect of hysteresis being as if the magnetic reluctance were increased; still another portion is wasted in setting up eddy currents in the transformer and, finally, yet another portion is not fully utilized on account of some of the lines of force set up by the current not being effectively employed, either through whole or partial leakage. The amount of magnetizing current depends upon the magnetic quality of the iron and the form and state of continuity of the magnetic circuit; the hysteresis depends upon the hysteretic quality of the iron, and the quantity of eddy and last mentioned current components depends largely upon the design. While in some cases each component of the "leakage" current may be reduced, in no case can the latter three be entirely eradicated, and the very principle of the transformer, of course, depends upon the presence of the first named component.

Water Power Electrical Transmission Plants.

The water power electrical transmission, plant described in another column by Mr. W. F. C. Hasson, is a typical example of Rocky Mountain and Pacific Slope electrical power development. In the East little attention has apparently been paid to the utilization of high heads of water, notwithstanding the advantages presented. At present, however, a somewhat similar plant is being installed in western Massachusetts, and it is likely that in the near future others will follow. As in the case of high buildings and some other developments which the East owes to the less timid enterprise of the West, at first the idea of using heads of water corresponding to pressures ranging from 100 to 600 lbs. per square inch naturally seems somewhat rash.

A high water pressure is quite different to control than a gas pressure on account of the additional element of inertia introduced, but in the far West the problems entering appear to have been very satisfactorily solved. An interesting example of one of the problems was presented at the Fresno (Cal.) plant, where the head is 610 lbs. per sq. in. A waste nozzle was provided, and when the water was turned on, the stream from it speedily cut a hole through the granite wall of the power house, against which it happened to be directed. When the stream was directed against a steel plate, the latter was soon pierced, and finally a large casting was made which is gradually fed to the stream as it becomes worn away. The great advantage of a high head comes from the cheapness with which it may be developed. In the plant described by Mr. Hasson, the entire cost, including buildings and electrical equipment, was slightly less than $100 per horse power, while the hydraulic development alone of a low head may vary from $60 to $140 and even higher.

220-Volt Lamps.

As will be seen from an article in another column, the use of 220-volt incandescent lamps in England is rapidly entering the commercial stage. It appears that in Manchester these high voltage lamps are already in regular commercial use, and the engineers of central stations in several other English cites report that they are giving excellent satisfaction, both to the station management and to the consumer. There does not seem to be any particular reason why it should be otherwise. 220-volt lamps of sixteen candle power, for example, do not necessarily differ from lamps of half the voltage, except in having an eight candle power filament twice the length of the filament of the lower voltage lamp. If eight candle power lamps, which have been largely used in Great Britain, have been efficient and durable, there seems no reason why the new high voltage lamps of sixteen candle power should not be equally so where the longer filament is not subjected to jarring.

As the saving in copper for 220-volt over 110-volt circuits is seventy-five per cent., the importance of the new departure is evident. Owing to the absence of the neutral wire, less copper is required than for the present Edison three-wire, 110-volt system, thus depriving the latter of its advantage over the present two-wire system; and it is to be demonstrated whether 440 volts can be adopted for use with the present Edison underground distributing system, owing to questions of insulation. House wiring where there is to be a considerable number of lamps, besides becoming much less expensive, would be greatly simplified on account of the smaller sizes of wire employed. The writer of the article which we abstract lays considerable stress upon the less fluctuation of voltage with 220-volt lamps, but why this should be so is not clear. For the same fluctuations of speed at the generator there would be the same percentage fluctuation in voltage and, therefore, the same effect on the lamps; and if the wiring is calculated for a given percentage loss in each case, the use of a higher voltage will not affect the drop.

Lord Kelvin.

The honors paid to Lord Kelvin last month upon the fiftieth anniversary of his professorship at the University of Glasgow, were unprecedented—whether as a testimonial of appreciation to noble personal qualities or as the homage of the entire scientific world to one who is recognized, without a dissenting voice, as not only its greatest living representative, but as one whose name ages hence will make the nineteenth century stand out in greater relief from having been the period of his labors. While surrounded during the jubilee by illustrious men of science from every civilized country in the world, Lord Kelvin had the pleasure—perhaps never before experienced by a savant—of knowing that, in spirit, homage was also being rendered by thousands in practical walks of life in recognition of achievements which, if less likely of immortality than those of the intellect, have been, and will long continue to be, of immense benefit from the utilitarian point of view.

One of the most useful lessons of Lord Kelvin's life is the confirmation which it gives of the definition that genius is "an immense capacity for hard work." It is only recently that, though passionately fond of yachting, he gave up the summer vacations on the water which for decades had been his recreation, on the ground that he could no longer spare the time from his work. A great part—perhaps the greatest—of the success met with by the innumerable apparatus he devised, was due to the remarkable attention he paid to every detail, however minute. The maker of his apparatus has stated that nothing was left to the manufacturer—every detail, even to the pitch of screws, being as carefully worked out as if upon each depended the entire success of the apparatus. In the marine compass, for example, a peculiar method of dovetailing was devised for the wooden case in order that it might better withstand the effects of dampness. Several years before the Kelvin balance was placed on the market, the writer saw the instrument apparently in complete state, but awaiting, he was informed, perfection in all of its various mechanical details before being put in course of commercial manufacture. Though one of the intellectual leaders of the century, Lord Kelvin takes the keenest interest in everything relating to industrial affairs. He is well known in all of the great shipbuilding and engineering works about Glasgow, which he periodically visits and notes with lively pleasure any advance brought to his attention. A personification of both the scientific and industrial spirit which has characterized the past half century, the kingly honors of which he was a recipient last month were peculiarly appropriate.

Compressed Air for Street Railway Traction.

In another column will be found some data concerning one of the two compressed air systems which will shortly be tried for street railway traction purposes in New York City. Owing to the refusal of the companies interested to divulge any information in regard to the details of the systems, the description we are enabled to give is rather meagre, but nevertheless, from it a fair general idea may be obtained of the main features of one system, from which the other differs only in detail. As will be seen, in place of the two motors of an electric street railway equipment with their simple gear mechanism and underground trolley connection, (rivalry with the overhead trolley apparently not being proposed), in the Hardie system there are substituted sixteen air tanks, a hot water heater tank, and two reciprocating slide-valve engines with their several exposed articulations and piston rod surfaces. In addition, there are a link mechanism, reducing air valves, a by-pass valve provision and driving wheels coupled by parallel rods—the latter arrangement being one which has been thoroughly tested in electric street railway traction and found wofully deficient. As to weight, the figure given for a Hardie car completely equipped is 9 tons, while the weight of an electric car of the same size is 15½ tons.

In efficiency the comparison between the electric and compressed air systems is not less unfavorable. In the former case we have a line loss averaging perhaps ten per cent. while in the latter there is a loss of thirty or forty per cent. in compression, due principally to the waste of the heat arising when a gas is mechanically reduced in volume or —which is the same thing—increased in pressure. Both in the generation and utilization of compressed air, the losses are higher than in the case of the electric system, and the danger from the explosion of one of the numerous tanks subjected to a pressure of 2000 lbs. per sq. in., is one much more real than any to which the passenger is exposed from the erstwhile "deadly trolley." What advantages the compressed air system has seem to consist only in the ability to use the steam engine under conditions of the best economy owing to uniformity of load, and in dispensing with street underground construction. Its advantages, however, did not enable it to prevail over horse traction in the attempts made before the days of the electric railway, and it is not unlikely that ulterior considerations may have led to this revival—a delay of municipal action with respect to the underground trolley in Philadelphia, and the extension of the overhead trolley in the upper part of New York city perhaps being the real objects in view. It is, of course, unsafe, and also somewhat unfair, to condemn any system whatsoever, in advance of practical trial, but where such emphatic claims of superiority have been made, as in this case, and without accompanying proof, it is not amiss to bring out the other side of the story.

A RÖNTGEN RAY OUTFIT—III.

THE CIRCUIT BREAKER.

Even to those that have every facility at hand, and are not limited to any definite cost, the circuit breaker is a difficult problem. In the preceding chapters it has been noted that the high voltage primary of many turns requires a special circuit breaker, so long and so lasting is the breaking arc due to the great self inductance of the coil. An ordinary vibrator in a nearly perfect vacuum, such as is used by Mr. D. McFarlan Moore, is very good for small currents. An inductive arc finds great difficulty in enduring in a vacuum. In large sizes, however, it becomes difficult to make the vibrator, for the hammer must be so heavy that its vibrations are very apt to crack the glass at the point where the wire to the hammer enters.

A vibrator is unsatisfactory for the reason that the time during which contact is made is not sufficiently long for the current in the coil to attain its full value, and sometimes the contact is for such a brief interval that the current attains a mere fraction of the value that it should have for maximum secondary effect. The tools for making the vacuum breaker are not to be had by the majority of people, and it is the object of this article to describe a circuit breaker for the purposes indicated which any one with ordinary tools and ingenuity can build.

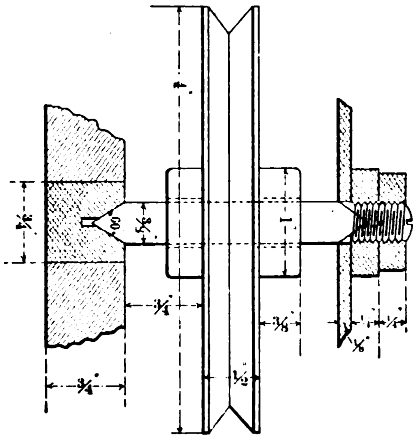

FIG. I.—ARBOR AND PULLEY.

This circuit breaker relies for its success upon its ability to open the circuit a very long distance in the brief interval of time that is consumed in the snapping of one of the stiff brass springs off the semicircular pins shown in Fig. 2. There are eight of these breaks in series, and as each of them is nearly one-half an inch in length, the circuit opens about four inches almost instantaneously. Comparing this with the gap of a vibrator, which is rarely more than $\frac{1}{32}$ in. in length, it will be seen that the gain is quite substantial, as indeed it must be to successfully operate a high voltage primary of many turns.

To make the apparatus, procure a piece of hard rubber, ½ in. in thickness, and a little over four inches square. Through the center drill a ⅜ in. hole. Make the little arbor according to the drawing (Fig. 1). A short piece of machinery steel $\frac{7}{16}$ in. in diameter will answer best. With it there will be ample stock to turn the threads, and allow for centering. If the facilities are not at hand, any good machinist will make the arbor for about fifty or seventy-five cents. If the commutator is to be a success, it must be well made.

Mount the hard rubber square on the arbor, and clamp it securely in place with the two nuts. Place the combination in a wood lathe and turn up the hard rubber into a four-inch grooved pulley, as shown in Fig. 2. With a sharp tool, mark a three-inch circle on the side, and with a pair of dividers divide this circle into eight equal parts. At each of these equal divisions drill a ¼ in. hole, such that it will be a driving fit for a ¼ in. copper rod. Insert in each of the holes a piece of this copper rod, 1½ ins. long, allowing it to protrude ½ in. on either side of the rubber disk. File each of these pins to a semicircular section on the part protruding, and adjust the pin so that its plane surface shall be at an angle of 45 degs. with the radius passing through its center, as shown in Fig. 2. This completes the rotating part.

The stationary part of the circuit breaker is mounted on a piece of hard wood, ¾ in. thick, and 6 ins. × 6 ins. in lateral dimensions. A ¾ in. hole is drilled in its center and a ¾ in. brass rod tightly driven in; being also ¾ in. in length it comes flush with either side of the board. This brass is drilled and reamed out with a 60 deg. countersink, and forms the lower bearing for the arbor of the pulley just described (see Fig. 1).

The upper bearing may be a brass casting, or a piece of ⅛ in. sheet brass cut and bent to shape as per drawing. If it be the latter, it must be reinforced at the middle by a circular disk of brass ½ in. thick and 1 in. in diameter; this disk may be sweated on with solder. If a casting is employed, which is preferable, this boss is, of course, cast on at the proper place. The center of this reinforced place is drilled and tapped with a ⅜ in. tap, and a screw with a female center sunk in its end is fitted thereto. This screw is locked in place with a ¼ in. check nut, and forms the upper bearing for the apparatus. The finished yoke is secured to the board with ½ in. round head brass screws.

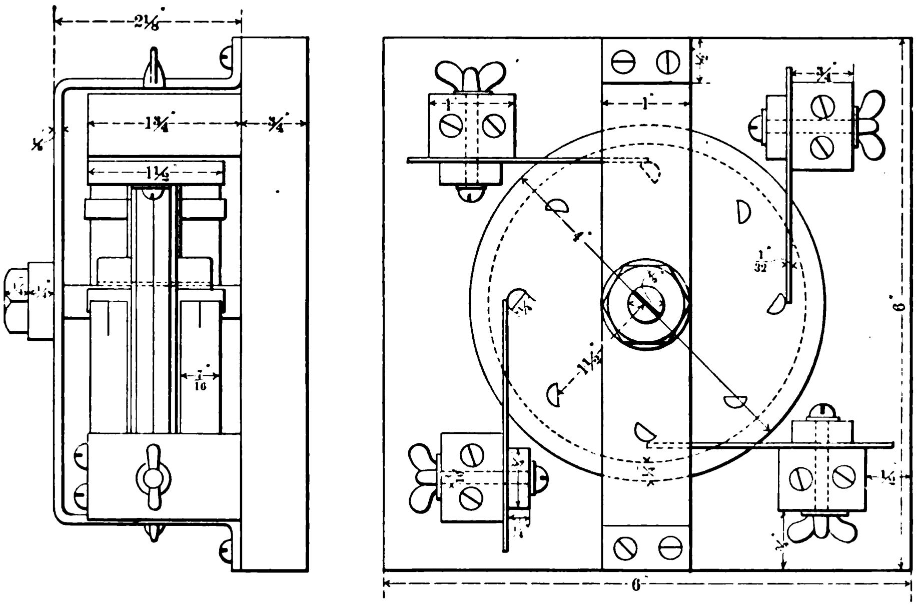

FIG. 2.—SIDE VIEW AND PLAN OF CIRCUIT BREAKER.

Next in order are four blocks of hard rubber 1 in. × 1¾ ins. × ¾ in. They are secured to the base board in the positions indicated, with two $\frac{3}{16}$ in. screw bolts each. A third screw bolt, provided with a thumb nut, secures a rectangular piece of hard rubber, ¾ in. × 1½ ins. × ¼ in., against the $\frac{1}{32}$ in. phosphor bronze strips that serve as brushes.

These brushes are $\frac{7}{16}$ in. wide. Each little hard rubber pillar carries two of them clamped by the thumb nut as shown. One brush bears on the upper, and one on the under, side of the disk—snapping from pin to pin as it revolves. It is important that each pair of brushes bear on the ends of the same pin and that all eight brushes snap from their pins simultaneously. The brushes should be given a set, so that when they snap from a pin they will almost strike the next one, thus opening the circuit as far as possible. It is not important that they simultaneously make circuit, but they should be carefully adjusted for coincident action on the break. It will be noted that there are four idle pins and four working pins. This is to secure a greater number of breaks per revolution, there now being eight. This enables the circuit breaker to be driven much slower. It may be driven by an electric motor or by hand with the aid of a balance wheel from an old sewing machine suitably mounted.

A very pretty way of driving the circuit breaker is to gear it by spur gearing to a second spindle with a ratio of four to one. On this second spindle is mounted on its geometrical center, a little rectangular piece of iron, about ¼ in. × 1 in. × 3 ins. thus revolving on its edge. The piece of iron is so placed that it will revolve its ends over the end of the core of the induction coil. The proper adjustment being made, the iron will revolve and drive the contact.

The principle is as follows: When the circuit is made, the core of the coil becomes magnetized and attracts the iron bar. The latter moves, and the contact snaps open just as the iron reaches a position exactly opposite the core. The momentum carries it by, the circuit is made, the other end of the iron bar reaches a position to be attracted, and the attraction and subsequent break of the circuit occur in precisely the same way as before. Thus the process is continuous. The action of this contact breaker is improved by the use of a condenser. It is not conveniently arranged for the employment of an air blast, and when the arcs are minute the latter is not so necessary. When the arc is of some size, the air blast is always superior to a condenser.

To an electrician the connections of this circuit breaker are obvious, but for the benefit of those who may be puzzled, it may be said that each pair of brushes may be regarded as the terminals of a battery as far as connecting is concerned; each set of brushes is to be connected in series precisely as a set of cells would be connected in series. The current should pass through each pair successively.

◆

FAULTS IN DYNAMOS.

There is a certain class of difficulties that occur with dynamos that cannot be properly classed under faults. These rather come under the head of blunders, but they cause the dynamo to become inoperative just as truly, and therefore deserve description in order that they may be readily detected and distinguished.

This class of troubles of operation arises from incorrectly assembling the machine, and improper connection of its electric circuits, this latter difficulty occurring in both field and armature. Of course, they never occur on a machine that has been satisfactorily operating for a period of time, but only with a machine that has been newly assembled.

The symptoms that appear on a machine that has been improperly put together or wrongly connected, are often different from those with which the average dynamo tender is familiar. The machine may build up a voltage less than the normal, and refuse to operate at the higher one; it may refuse to generate, and yet give ample evidence of electrical energy by furiously sparking at the brushes; it may get abnormally hot on no load, or it may refuse to generate at all.

Most of these so-called blunders are due either to incorrect connections of the field or of the armature. Most often the mistake is committed by the man who puts the machine together in the station, though sometimes a machine will be found that has left the factory improperly connected. In this section we will consider those blunders which arise from incorrect connections of the field magnets. These cases naturally divide into three classes, referring to the simple shunt machine, the series machine, and the compound machine. The symptoms of improper field connections are usually the refusal of the machine to generate, or its generation of a voltage below the normal. Occasionally, on multipolar machines with as many armature circuits as poles, incorrect field connections result in the general overheating of the armature. Often the regulation of the machine is poor, the voltage falling rapidly as the load comes on.

The fields of a dynamo may be incorrectly connected in any one of the following ways:

1. The coils may be so connected as to oppose each other in magnetic effect.
2. The coils may be so connected as to destroy the magnetic field that generates the current that energizes them.
3. The coils may be short circuited.
4. The field coils may not be connected at all.

Taking first the case of the simple shunt machine, the last named difficulty of disconnection of the coils is quite a common one, although it is obviously a mistake to any one familiar with the first principles of dynamo machines. Such a mistake is, therefore, an oversight. If this trouble is suspected, open the shunt circuit at a convenient point and try to ring it up with a magneto. If no ring results, keep one terminal of the magneto where it is and with the other touch the wire connecting the two field bobbins together. If this rings up, the open place is in the other half of the field magnet circuit, which should now be taken and subdivided into sections for testing in a similar manner, until the open place is run down. By this means the mistake will be soon found, even if the magnet is a large multipolar one. Remember that the field magnet circuit includes the rheostat and the wires leading thereto, and that the open place is more liable to be here than anywhere else. Often the magnet bobbins are not connected together, the manufacturer perferring to ship them in that condition to avoid their terminals being broken close off to the bobbin in transit.

While it is always better to mistrust your own work in the matter, it is by no means certain that because the manufacturer has delivered the machine, that it is all ready to run with the making of the connections to the switchboard. Necessity or negligence may rule otherwise, and besides, the dealer is not to be held as infallible. He has the same human failing of making mistakes as any one else, although in this case he is less liable to do so than the buyer of the machine.

The first case named is that of connecting the coils so that they oppose each other. This results in a lower voltage or, if the coils are two in number and equal in size, in no voltage at all. If the coils of a pair of pole pieces are equal and opposite in magnetizing power, the poles themselves will attract the same end of a compass needle when they should attract alternate ends. It will be found also that the yoke of iron connecting the rear ends of the poles thus improperly connected will become strongly magnetic when the field is energized by a current. Indeed, if this trouble is suspected, a very pretty way is to strongly excite the field of the dynamo from an outside source, keeping the armature stationary. The field may then be tested for such abnormal developments of magnetism with a small piece of iron.

A little study may be necessary to determine which is the yoke piece on some machines. Thus on a Thomson-Houston dynamo of the spherical type, the yoke would be the bars on the outside of the machine, and if the coils were connected in opposition, these bars would become highly magnetic. In an upright Edison dynamo, the magnetic portion in the case of such a misconnection, would be the rectangular yoke piece on the top of the machine.

In testing the polarity of strong magnets with a compass, care must be taken that the compass is not placed too near the magnet. Two feet is an ample distance, and if a nearer distance is used, the magnetism of the compass is liable to be reversed and throw the tests into confusion.

Some dynamo machines have their field coils arranged in sections, for certain reasons, and occasionally one of these sections is so connected as to oppose its fellows, but being one in many, it may not be sufficient to cause complete reversal of the pole piece it surrounds. In such a case the compass method can be profitably employed. Let the compass be placed at a certain measured distance from a pole piece that is suspected to be weakened by the reversal of one of the sections of its bobbin, and set the needle swinging. Count the number of complete vibrations that occur in a minute. Place the compass in a similar position with regard to the other pole piece known to be of full strength and repeat. The stronger the pole piece, the more rapid these vibrations will be. The frequency of the vibrations varies directly as the square of the strength of the pole piece, provided that the compass is attracted by no other force than that of the pole piece tested. In making this test care must be taken to see that the current in the field circuit is kept exactly constant. Its magnitude matters not provided that it is sufficient to produce a good strong field likely to predominate over outside influences.

If the coils are so connected that they work against the magnetic field that generates current to energize them, the machine will as a whole refuse to build up its voltage. On suspecting this trouble, interchange the shunt field terminals, and try the machine again. If the machine is still obstinate, try the ordinary methods of inducing self excitation. It may be that the repeated trials with the fields wrongly connected have killed the residual magnetism, and that the machine requires a start. Give the machine time to build up; machines have been known to take as long as five minutes to get up to full voltage. The experimenter in his anxiety to have things work right, may, after a moment's trial, decide that his connections are wrong, and change them when success would have attended a little patience. Particularly is this the case when a pilot lamp is the only means of telling that the machine has come up, or is coming up to voltage. A machine might build up considerably without causing the filament to glow.

If the field is short-circuited, of course practically no current can enter it, and the machine will refuse to generate. Short-circuitings of this nature generally take place through the frame, and to do this there must be two grounds, one at each terminal of the field coil. A magneto will readily detect a ground, and if one is found and there is refusal to generate, two may be suspected. To verify these suspicions, open the field circuit in the middle, and ring between the field terminals. If this rings up, the fields are certainly shunted, and probably short-circuited. In testing thus for a short circuit on a shunt machine, be sure that the brushes are lifted. If this precaution is not taken, the experimenter is pretty certain to find a very solid short circuit, one, however, that is legitimate—namely, the armature of the machine.

A series machine differs but little from a shunt machine in its false field connections, and the effect thereof. Open circuits and short circuits produce the same effect—namely, refusal to generate—and these troubles are sought for in a similar way. On series machines it is well to remember that the entire outside circuit is a portion of the field circuit, and upon its continuity the field magnet depends for its current. Coils in opposition on a series machine may be detected by the method of testing with separate excitation already described.

Series machines are usually high voltage arc machines, and even if the bobbins are in opposition, there may be a furious electrical display at the commutator when the machine is run. Particularly is this the case if the machine is of the open coil type. Series field coils so connected as to "build down" the machine, are detected and corrected as with shunt machines.

Compound machines possess both a shunt and a series coil, and though the independent treatment of these coils is very similar, yet the mutual action of their combined presence complicates the search after incorrect field connections. The series coil on a good machine is of low resistance, and is designed to be inferior to the shunt in magnetic power. In a compound dynamo a series coil is simply a regulator, and when it is improperly connected the regulation will be affected. If it be left out altogether, the machine will not regulate at all, but will lose its voltage as the load comes on, the same as in the case of an ordinary shunt machine. If the series coil opposes the shunt coil, the effect just mentioned will be enhanced.

A good way to determine the correctness of the connections of a series coil, is to run the machine with a load, and short circuit the series coil, at the same time observing a voltmeter placed across the terminals of the machine. If on short circuiting as indicated, the reading is lower than at first, the series coil is properly connected. If the reading goes up the series coil is reversed with reference to the shunt, and should be correctly connected by interchanging its terminals. If no effect on the reading is produced, the series coils are in opposition or are out of circuit. This latter case frequently arises, for often the numerous studs confuse the person making the connections, with the result that the armature terminals become the machine terminals, thus cutting out the series coil. Series coils out of circuit may be distinguished from coils in opposition by the fact that when the latter are short circuited and then open circuited, a slight spark occurs, while with a coil out of circuit no such spark can be observed.

If the shunt circuit is open, the series coil being intact, the machine will refuse to generate full voltage, but on short circuit will develop enough current to fuse a relatively stout copper wire. This of itself indicates the difficulty. Shunt field coils on compound machines are treated for incorrect connections in practically the same way as on simple shunt machines. In a following section the various mistakes sometimes made in connecting the armature will be taken up and discussed.

REPAIR OF ELECTRIC RAILWAY APPARATUS.

BY W. E. SHEPARD.

The Westinghouse Motor.

Three types of Westinghouse motors have been put before the public, which have met with very general use.

The earliest, known as type 3, was first sent out in 1890, and for five years held the field as the acknowledged motor of this company. In 1894, type 12 was brought out, and in 1895 type 12 A became standard.

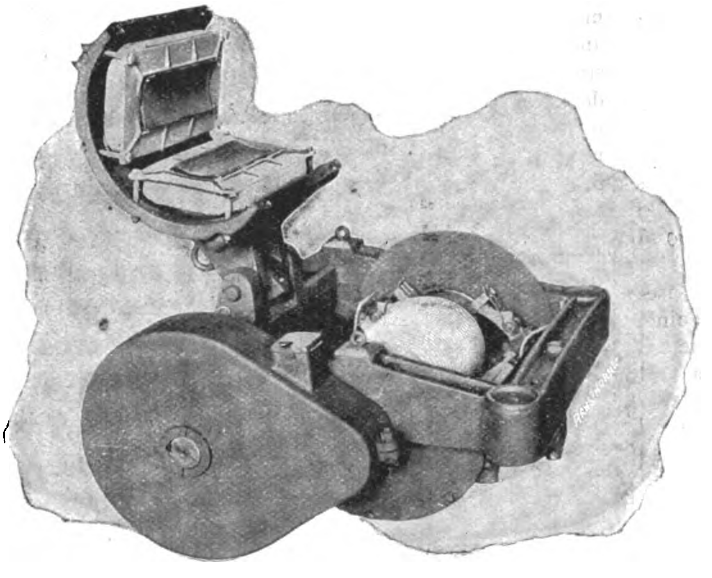

FIG. 1.—NO. 3 SINGLE REDUCTION RAILWAY MOTOR.

Owing to the considerable length of time during which type 3 was produced, there is probably a larger number of these motors now in use than there is of any other single Westinghouse type, and that they were an extremely good motor is borne out by the very considerable number which are continued in service right along with those of later and more approved pattern.

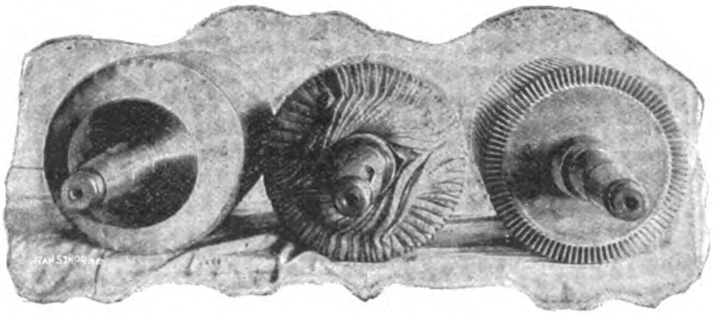

FIG. 2.—TYPE 2 WESTINGHOUSE ARMATURES.

Fig. 1 gives a general view of this motor, with armature in place and upper fields thrown back.

The motor proper consists, as may be seen, of a cylindrical shell cut in halves horizontally, each half being hinged at its back so that either the top or the bottom half or both may be swung back, exposing both the armature and field coils, either of which is readily removed as desired.

The cylindrical shell is supported by a heavy hollow rectangular frame, itself supported by springs on the one end and by the car axle on the other. The prominent feature of this motor is its strong mechanical construction.

It is a four-pole machine, without consequent poles; that is, each pole is arranged with an energising field coil of its own. The armature is of the double-circuit cross-connected type, and was the first to use the slotted core with the coils sunken below the surface.

The motor is so constructed that all work is done on it from beneath the car, excepting only inspecting and filling of the lubricating grease cups. This, of itself, is a very great advantage, doing away, as it does, with all portable apparatus which, in other types of motors, must be used in the inside of the car body, and allows of special and convenient arrangements from below for use in replacing armatures and other heavy and dirty work which would necessarily be done inside the car itself when the armature is accessible only from above.

The armature shaft in this motor is quite heavy, being 2½ ins. in diameter. Notwithstanding this, it will occasionally become sprung, and in this event the matter of repair is a serious one. The shaft is not arranged to drive out, and in most cases it becomes necessary to remove the winding, as otherwise it is almost certain to become damaged by the heat necessary in the process of straightening. In cases where the bend in the shaft is at the pinion near the extreme end of the shaft, a cylinder of heavy sheet asbestos about six inches in diameter may be made, with one end closed up and a hole cut in the other of a size just sufficient to allow the end of the shaft to pass through. This being slipped on over the end of the shaft, by the use of several heavy gasoline torches, the shaft may be heated sufficiently to straighten, which process must, of course, be done in a heavy lathe. As an additional precaution, the armature may, beforehand, be given several heavy coats of shellac or P & B compound, particularly on the head next the pinion, and over this several rings of canvas placed which, during the process of heating, may be kept thoroughly wetted so as to keep down the heat from the windings of the armature.

When these armatures are being rewound,

it is a good plan to start the winding at such a point that the small set-screw in the collar which holds the core to its position on the shaft, shall come just between the opening formed between the third and fourth quarters of the winding. When the coils are put on in this way, in event the shaft becomes badly bent, this set-screw can be removed by a side screw-driver and the collar backed off by blunt chisels and the armature shaft driven out. When this can be done, the straightening can be accomplished much easier and more accurately than when the shaft is in place in the core.

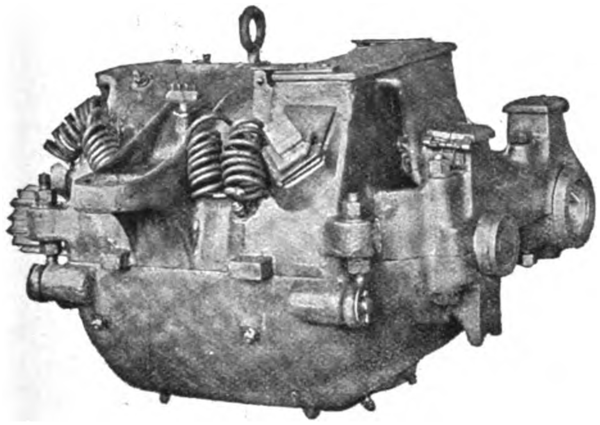

FIG. 3.—NO. 12A RAILWAY MOTOR, CLOSED.

In repairing the field-coils of this motor, it is generally a good plan to insert a heavy strip of sheet mica between the first and second layers of tape used as a wrapping. The mica should extend from corner to corner on the outer edge of the coil, on the end nearest to the commutator, as it is here that the field-coil most usually breaks down. It is well also to insert a heavy fuller-board washer between the coil and the motor frame, and another between the coil and spider which supports it.

This motor is built with the main axle caps removable from below. This arrangement allows of the easy removal of worn out or damaged wheels, either by raising the body, truck and motors up free of the wheels, as is done where heavy traveling cranes are accessible, or by removing a short portion of the track and taking the wheels out from below. Where the axle caps are bolted above the bearing, as is the case with some later types, it becomes necessary to first remove the motor entirely from the car, and afterwards the wheels, requiring considerably more work than when arranged as in this motor.

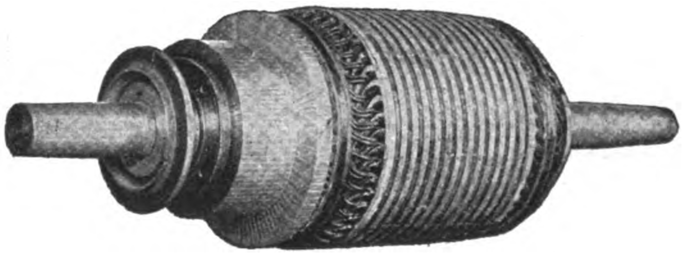

FIG. 5.—VENTILATED ARMATURE FOR NO. 12A RAILWAY MOTOR.

One feature of this motor, and one which has contributed very largely toward its success, is the accessibility for inspection of the condition of the bearings. By removing a guard which is bolted at either end of the bottom of the motor, the exact clearance of the armature from the face of the pole-pieces is easily seen, and may from time to time be readily measured by a taper gauge and recorded. This is a feature which has not been appreciated, or at least has been overlooked by designers, as none of the later designs are accessible for such inspection, and the only way to know the condition of the bearings is by means of records of mileage of the car, and this method must presuppose a uniform and reliable action of the bearing.

Two openings are left in this motor, one at either end on the upper side, which expose the interior to water and mud from the wheels, and to snow. These were left for circulation and ventilation, but it will be found desirable to use covers over each, especially during stormy and wet weather. Such covers can be easily made from sheet iron having lugs riveted at each end for supporting them in place.

It was a desire to secure a more thoroughly waterproof as well as a lighter machine which led to the fundamental changes in the succeeding type 12 motor. In this motor, the type remains nearly the same as in the one just described. It has the same four fields and the same cross-connected, double-circuit armature, the chief difference being the omission of the heavy supporting yoke or frame, and the incorporation of the armature-bearing supports into heads or ends completely incasing the interior of the motor.

The armature is slotted for but half the number of coils; each coil, however, is double, so that in reality there is no change. The body of the armature is much shorter and is arranged to be lowered only from the under side, the upper field casting being stationary.

The latest type, known as type 12 A, is very similar to the one last named. The frame is moulded to a rather better and more substantial outline, and the armature wound after the "Eickemeyer" style of winding. The coils are all wound on forms and shaped before placing on the armature. They are of two sizes, inner and outer, and symmetrical; when placed on the armature, a passage is left between each coil and between the two heads formed by the inner and outer layers, thus allowing of considerable facility for ventilation at the ends of the armature. The 12 A motor is shown in Figs. 3 and 4.

Fig. 3 is a very good view of the motor as it appears closed, and Fig. 4 shows the lower half of field dropped down, exposing the armature in place. Fig. 5 gives a general view of the armature of this motor, showing the ventilating spaces at the heads referred to.

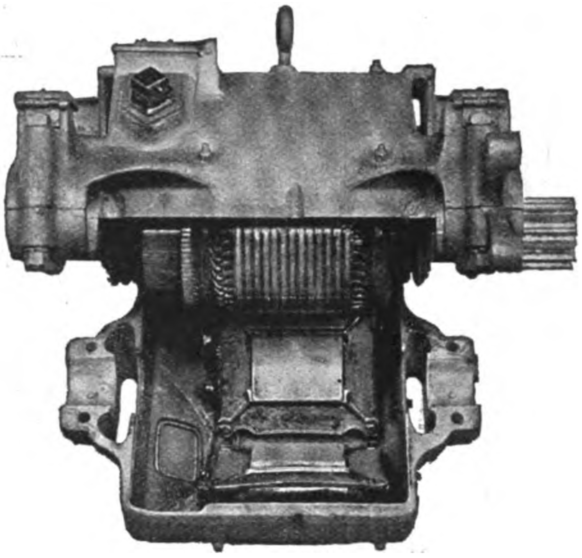

FIG. 4.—NO. 12A RAILWAY MOTOR, OPEN.

A LARGE SILVER MINING ELECTRIC PLANT.

Some months ago an interesting power transmission plant was installed by the General Electric Company at the Silver Lake mines of Mr. E. G. Stoiber, at Silverton, Col. The introduction of electricity into the operation of the mines resulted in an economy so noticeable that an increase in the plant is now being made to provide for an extension of the system in the mines, and to reinforce the water power, which is not sufficient to furnish all the power required throughout the year.

The difference between the cost of coal at the power house and its cost at the mine, which is at a greater elevation by some 2500 ft., is such that the saving effected, even when steam power is used for generating purposes, will insure an ample return on the investment.

The present plant now in operation consists of two 150-KW General Electric three-phased, water-driven generators, supplying current to one 100-HP motor for the mill; one 100-HP motor for the air compressor; one 75-HP motor for the hoist; one 15-HP motor for the pump; one of 1-HP for a blower, and to incandescent lights scattered throughout the station, mill and mine. The additional plant will consist of two 150-KW General Electric generators; one 100-HP motor for the mill; one 15-HP motor to drive a pump, and two 10-HP motors for driving blowers, forges and miscellaneous machinery. This, although the entire output of electrical energy is to be used in the operation of a single mining property, will be the largest electric power plant in the State of Colorado.

INTERIOR WIRING.

THE DESIGN OF CIRCUITS.

After the lamps of an installation have been located, it is necessary that they be connected together with wires in such a way as will give the most uniform distribution of pressure, and, at the same time, afford appropriate control, both as regards switches and fuses. There are, therefore, two principal considerations in the design of circuits—uniform pressure, and methods of control. Both of these should be accomplished with the least copper possible.

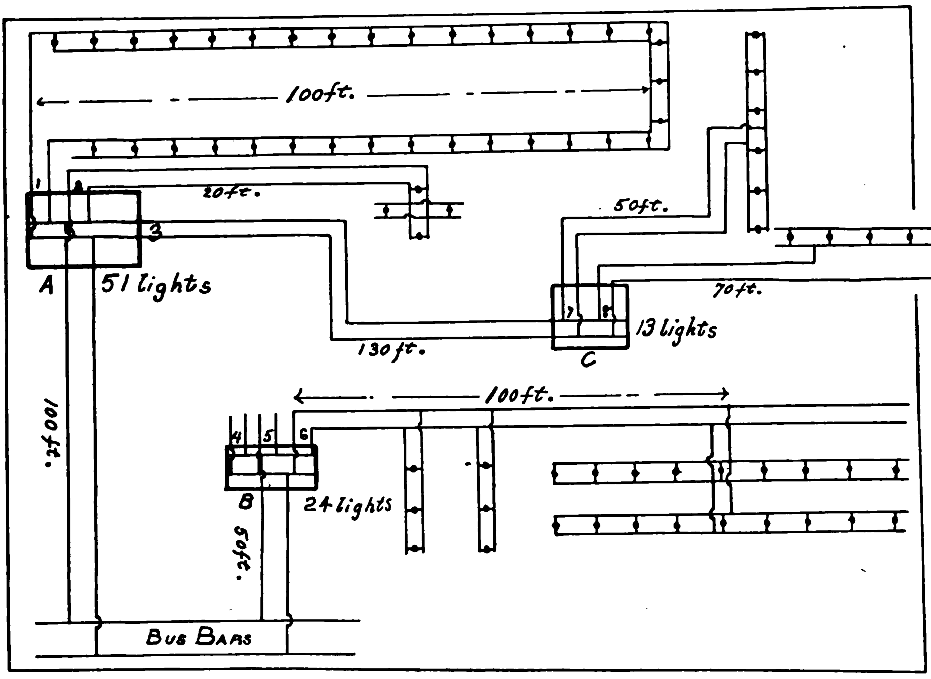

FIG. 1.

There are two great systems of interior wiring—1°, the tree or feeder and main system, and 2°, the cabinet or closet system. Fig. 2, shows a good example of the feeder and main system, and it is in a measure self-explanatory. Large wires feed the center of the system, which consists of a pair of mains, and these in turn feed submains, from which branch the taps supplying the lamps. This system is largely used in factories, machine shops and weaving or carding rooms, where the lamps are so arranged that such a system is applicable, and where all of the lamps are to be used at once. For the majority of other places it is not suitable, except on a small scale.

The cabinet system consists simply in feeding with a pair of mains a set of bus bars in a small cabinet, from which circuits branch to the lamps or to sub-cabinets (see Fig. 1.) The circuits are always controlled at the cabinets with a fuse and often with a switch. These cabinets are cases built into the wall and finished in accordance with the wood work in the vicinity, and had best be arranged to lock, in order to prevent the intermeddling of curious or malicious persons.

Most of the modern installations are a combination of the cabinet and feeder systems. For instance, in a large office building it is customary to control each floor at the dynamo switchboard, and this is conveniently done by feeding a cabinet located in a central position on the floor to be lighted. From the cabinets run a number of sub-feeders spreading over the floor, and from these feeders tap the various office circuits. By this means the fuses of the circuits are readily under control, and any group of offices may be cut out as desired. Moreover, if a fuse blows, the cause may be readily traced and removed, and the cabinets can be all under the convenient inspection and control of one person.

The general ideas of the two systems being understood, it will be well to consider the units of which they are composed. First, there is always the main feeder, which carries the whole current used by the lamps. Then come the sub-feeders that carry the current of a portion of the lamps, and lastly the tap circuits. The main feeders are always the easiest to calculate. Taking, for instance, the feeders of Fig. 1, that feeding cabinet *A* carries the current of fifty-one 110-volt lights, one hundred feet. Assuming the maximum variation of pressure to be five volts from bus-bars to lamps, we may allow two volts loss in these feeders, which leaves three volts for the taps and sub-feeders. The line loss is 2, the lamp-feet 5100, and applying the formula for 110 volts, $R = \frac{E}{NF}$, we have $\frac{2}{5100} = .00039$ ohm per foot of wire, which is equivalent to No. 6 B. & S. wire, this being just a little large. If it were decided to have three volts drop on this feeder, No. 8 B. & S. would be the nearest size, it also being a little small. In this case it would be better to use the No. 6 wire, for it is always preferable to have the mains large rather than the sub-wiring, as the latter can be more easily changed if at any time it is desirable to increase the lights on the sub-circuits. Also, it is cheaper to scrap small wire than large.

The little chandelier (circuit 2) carrying four lamps 20 ft. away from the cabinet, involves but 80 lamp-ft., and the volts lost must be three in order that the loss be uniform from bus-bar to lamp socket in every case; applying the rule, the resistance per foot will be $\frac{3}{80} = .0375$. This is much higher than the resistance of No. 14 wire, but nevertheless we must use No. 14 because the insurance code permits no smaller. The lights on this chandelier will therefore burn above candle power.

Circuit 3, which feeds cabinet *C*, figures out 1690 lamp-ft. The line loss must be less than three volts, for we must have something for the inevitable loss in circuits 7 and 8, as we cannot make these wires of no resistance. Let the volts lost in circuit 3, therefore, be 2, and the resistance in ohms per foot is $\frac{2}{1690} = .0011$—most nearly No. 10 B & S. If we allow .75 volt for the circuits 7 and 8, the wires will be No. 14 on the fifty-foot circuit and No. 12 on the seventy-foot circuit respectively. The taps feeding the lamps are so short and carry so few lamps that it is probable that the wire would figure out nearer No. 20 than anything permissible. As before stated, No. 14 would have to be used, the drop through which would be negligible; but in all probability the contacts in the rosettes and sockets would absorb .25 volt so nearly that the

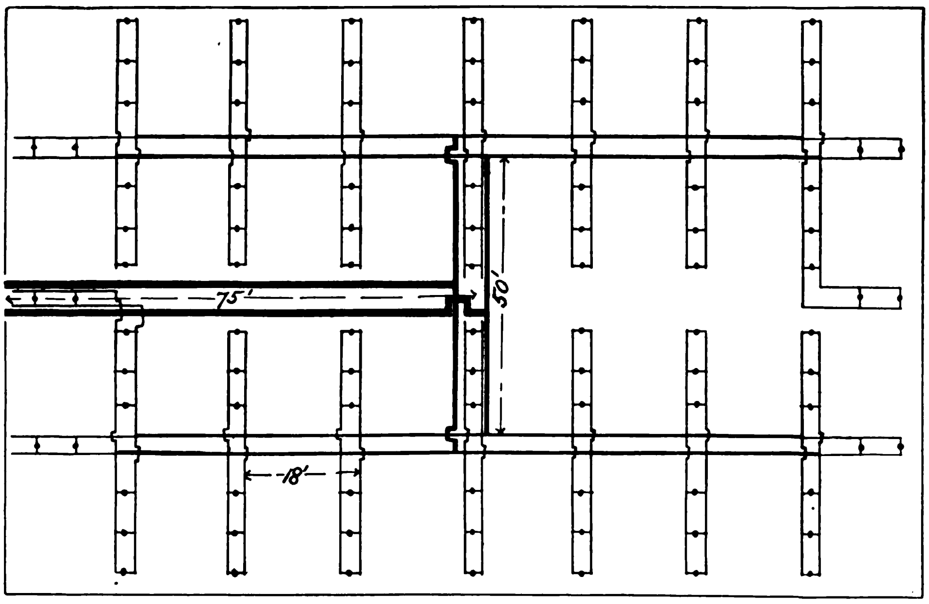

FIG. 2.

lamp voltage would be within that amount of the rating.

In making any calculation, it is not necessary to be any more accurate than the method. In calculating wire, we are handicapped in accuracy by being obliged to choose wires that are too large or too small simply because they are the nearest thing that we can get, or because the insurance code compels their use. We therefore can afford to approximate in such cases as this without practically impairing the accuracy of the result. It should be endeavored, however, to compensate as much as possible for these enforced errors. If we are obliged to choose the mains a little large, take advantage in the calculation of the sub-feeders to choose them a little small.

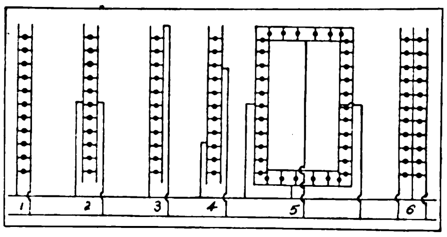

FIG. 3.

Turning now to the circuit marked 1, Fig. 1, it will be seen that it is somewhat different from any that we have yet encountered. If we were to calculate the wire for this circuit with scrupulous accuracy, we would find that the wire between every lamp would be of a different size. This would be a difficult circuit to run and would involve many joints. In fact it would not pay to be so accurate, for in many places the difference in the sizes of the wires between the lamps would be so small that the wire gauge would not follow them; that is, we are compelled to use one size of wire for all of these leads. It would not be advisable to piece the circuit anywhere, because the joints are troublesome and introduce an element of insecurity into the work. It is far better to use a uniform size of wire, for if it be too small on one side of the circuit, it will be correspondingly too large on the other, and thus a balance of the errors will obtain.

The proper wire can always be found conveniently in such a case by assuming that all the lamps are bunched together at a distance from the source of supply equal to one-half the length of the circuit. In this case the distance is 100 ft., and as there are 34 lamps we obtain 3400 lamp-ft. With three volts drop, the wire would have a resistance of .00088 ohm per ft., the nearest size being No. 9 B & S.

This method of wiring is called the loop circuit. It will be noted that the length of wire from bus-bar to lamp is exactly the same and, it may be added, the drop is nearly so. For this reason, this circuit is quite a favorite, as it meets the demands of equalized pressure. It is not economical of copper except when there can be a complete loop of lamps; it would never pay to run it as in 3, Fig. 1. Large loop circuits involving many lamps and long distances call for a wire so large that it cannot conveniently fit in the lamp rosettes and fixtures.

Tap circuits are of various kinds, and examples of them are shown in Fig. 3. No. 1 is the ordinary tap circuit fed at one end. Unless it is very short and has but few lights the last lamp will burn at a noticeably less brilliancy than the first one. No. 2 differs from No. 1 in that it is fed in the middle. By this means the lamp at the end is not so far removed from the source of supply, and such a circuit could be twice as long as one of the No. 1 type without affecting the relative brilliancy of the lamps it feeds in any greater degree. No. 3 is the loop circuit already described, and gives better distribution than No. 2. No. 4 gives even better distribution than No. 3, but is not as convenient, for it uses two single-pole branch blocks instead of one double-pole block. No. 5 is a method sometimes used on large rectangular chandeliers, rows of border lights, and in similar cases. It is not used often, for the numerous feeders must be brought to one point in order that the circuit may have appropriate switch control. A loop circuit would almost always be better. No. 6 is illustrative of a system which is adapted to either the three or two-wire system; it is very important, for many plants are wired on this system, so that they can operate on the two-wire system with their own power and, in case of a breakdown, the three-wire mains of the local lighting company could be called into play by the mere throw of a switch. It is obvious that this circuit can be fed in the same ways as 2, 3, 4 and 5, as may be desired.

In small tap circuits it is rarely necessary to calculate the wire, provided not more than five or six lamps, and those in close proximity, are to be fed. If the calculation is made, the proper wire will be found to be smaller than No. 14, and as the latter must be used to comply with insurance rules, no benefits are obtained from the calculation.

The calculation of an electric circuit may be summarized as follows:

First, divide the circuit into sections, such that each section carries as nearly as possible the same amount of current throughout its length. This necessitates, wherever circuits branch in the system, that this point must be a dividing line between sections.

Second, calculate the number of lamp feet that each section involves, remembering that each section is to be credited with the lamps on the tap circuits that it feeds by branches and taps, as well as those that it feeds directly.

Third, choose a line loss. By carefully choosing this you may avoid odd sizes which are inconvenient and not largely kept in stock. Remember that the line losses by any path from switchboard to lamp socket should, theoretically, sum up to the same predetermined amount.

Fourth, calculate the resistance by the rule already explained and select the wire. In selecting the wire, it is well to remember that if the feeder has been taken the size larger than the calculation called for as being the nearest, that it will be well to select the tap wire the next smaller size to equalize the drop. In choosing wires as the result of the calculations, arrange, if possible, to have the cases where the next larger wire is chosen, those of the main feeders.

Fifth, be careful to note that you are not installing wire that the insurance code declares to be too small. With moderate line losses there is little danger of doing this, but cases arise where the circuit feeds lamps very near the switchboard, and where, in order to get the drop, a smaller wire than is allowed is called for by the calculations; such a case was that of circuit 3, Fig. 2.

Lastly, remember that the line-loss, lamp-feet rule only applies to cases where both wires of the circuit are considered. Single wires are treated differently.

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The Indicator Card.

As the indicator card illustrated in the article under the above caption in the June number was distorted somewhat in inking and in the process of engraving, it is reproduced herewith, accompanied by the values of the pressures corresponding to the card as engraved. By adding the pressures, the mean values thus determined will be found 64.4 lbs. for card *A* and 61.1 lbs. for card *B*. By adopting the preferable method and adding the pressure lengths on a long slip of paper, the total length for card *A* will be found 10 $\frac{1}{16}$ ins., and 10 $\frac{3}{16}$ ins. for card *B*; as the scale of the spring was 60 lbs., the second method gives a total of 641 lbs. for card *A* and a total of 611 lbs. for card *B*, the averages being, therefore, 64.1 lbs. and 61.1 lbs. respectively, which give a final average of 62.6 lbs.

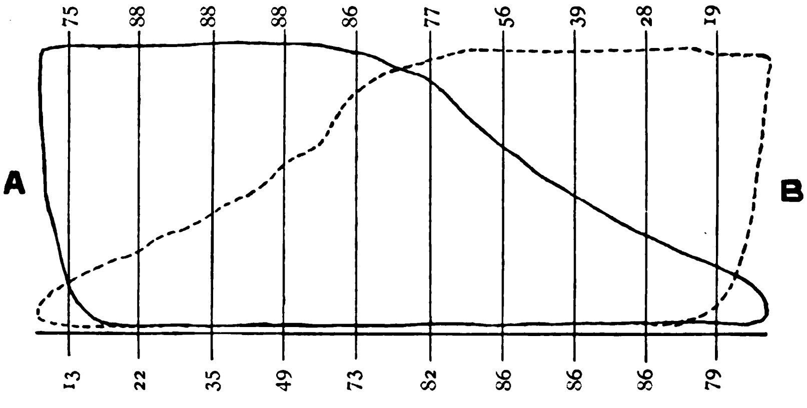

FIG. 4.

An error was also made in calculating the engine constant through taking the area of a 28 in. cylinder at 625 sq. ins. instead of 615 sq. ins. Allowing for a 2 in. piston rod (area = 3 sq.ins.), the mean area is $\frac{612 + 615}{2} = 613.5$, and the corrected engine constant becomes $\frac{2\,A\,S}{33000} = \frac{2 \times 613.5 \times 3}{33000} = .1115$.

With a mean pressure of 62.6 lbs. and 114 r. p. m. the horse power thus becomes $C\,R\,P = 115 \times 114 \times 62.6 = 796$ I. HP.

An interesting application of the indicator card is to the calculation of the amount of steam used per hour per horse power. It should be understood at the beginning, however, that the results of such calculations can be accepted as only approximate. The calculation is based upon the assumption that the steam works like a perfect gas, there being neither condensation nor re-evaporation. In reality, when steam enters an engine cylinder a greater or less quantity is condensed and a still further quantity during expansion. On the other hand, as the pressure falls during expansion, some of the condensed steam is re-evaporated, but how much cannot be known except by direct measurement, the amount depending upon the quality of steam, type of engine, whether jacketed or un-jacketed, the point of cut-off, etc. By the use of superheated steam, it may be remarked, the loss incident to the above condensation on re-evaporation can be largely avoided, and it is quite probable that before long general advantage of this fact will be taken in practice.

The steam consumption obtained by the method which will be explained, is always a minimum, the true amount being as much as thirty per cent. higher in some engines, but with a much less discrepancy in large slow-running engines. It is very useful, however, for an engineer to occasionally calculate a card for this purpose, for the reason that he may thereby be enabled to detect piston or valve leakage, and besides, obtain at least a comparative idea of the efficiency of his engine.

The clearance of one end of the engine must be known to commence with. While in perhaps every case this may be obtained from the engine builder, it is much better to measure it personally, as some builders may be inclined to put the figure too low on account of its commercial importance. To determine this quantity, it will be necessary to remove the valve cover and, the engine being on its head center, close the lead opening of the valve watertight. Then, the water valve being closed, pour water into the cylinder through the indicator opening, carefully weighing the amount used.

Suppose the size of the engine to be 28 ins. × 36 ins., and that fifty pounds of water are required to fill the clearance space, which includes the valve passages, the space between the piston and head and the cock opening. Since one cubic foot or 1728 cu. ins. of water weighs 62.5 lbs., the space occupied by 50 lbs. is $\frac{50}{62.5} \times 1728 = 1382$ cu. ins. The area of the 28 in. piston is 615 sq. ins., so that the part of the stroke corresponding to 1384 cu. ins. is $\frac{1382}{615} = 2.25$ or $2\frac{1}{4}$ ins. That is, the clearance space takes as much steam as is required for $2\frac{1}{4}$ ins. of stroke of the piston. Adding this to the stroke, we have $38\frac{1}{4}$ ins., and $\frac{2\frac{1}{4}}{38\frac{1}{4}} = .06$ or 6 per cent., which is the usual way of expressing clearances.

We are now prepared to take up the calculation of steam consumption. What we wish first to know is the quantity of steam contained in the cylinder at a selected point of the stroke. In order that the least condensed water may be included, this point should be taken at or very near the point of release, as at the point *d* in the diagram, referring to the full-line card.

Carefully measuring the length of the atmospheric line, we find it to be $3\frac{26}{32}$ ins. long; similarly, we find, measuring along the atmospheric line, that the point *d* is $3\frac{17}{32}$ ins. from the beginning of stroke. The fraction of stroke to point *d* is then $\frac{3\frac{17}{32}}{3\frac{26}{32}} = .926$ stroke, or $.926 \times 36 = 33.33$ or $33\frac{1}{3}$ ins.

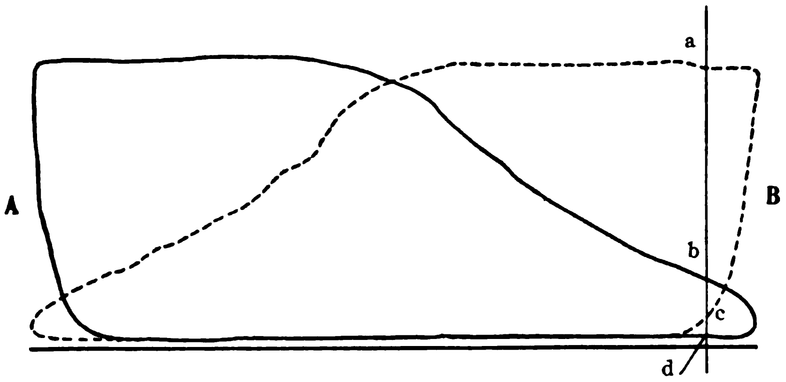

FIG. 5.

Next will be to find the quantity of steam that will occupy the space in the cylinder when the piston is $33\frac{1}{3}$ ins. from beginning of stroke. Adding the clearance of $2\frac{1}{4}$ ins., we have $35\frac{7}{12}$ ins. for the equivalent length of the space, whose area is the area of the piston, or 615 sq. ins. The volume occupied is then $615 \times 35\frac{7}{12} = 21{,}884$ cu. ins., or $\frac{21884}{1728} = 12.66$ cu. ft.

The next step is to find the weight of the 21,884 cu. ins. or 12.66 cu. ft. of steam in the cylinder at the point *d*, and to do this the pressure there above the atmosphere must be measured. The distance of *b* above the atmospheric line is $\frac{11}{32}$ in. which, as the scale of the spring is 60 lbs., corresponds to $\frac{11}{32} \times 60 = 20.6$ pounds. The weight per given volume of steam at this pressure may be obtained from steam tables, but it will here be calculated by an approximate method, as this can be very simply done and with sufficient accuracy.

The volume of a pound of steam at atmospheric pressure or 14.7 lbs. above a vacuum, is 26.37 cu. ft., and the volume of steam at another pressure (also expressed above a vacuum) is proportional to this, being, of course, greater if the pressure is below the atmosphere, and less if above. In this case, the pressure is 20.6 above the atmosphere or $20.6 + 14.7 = 35.3$ lbs. above a vacuum. Therefore, the volume of a pound of steam at that pressure is $\frac{14.7}{35.3} \times 26.37 = 10.94$ cu. ft. Therefore, since one pound of steam at a pressure of 20.6 lbs. above the atmosphere has a volume of 10.9 cu. ft., the volume of steam in the cylinder at the point *d* just before release will weigh $\frac{12.66}{10.94} = 1.16$ lbs.

If the piston makes 224 strokes per minute (114 revolutions) or 60×224 strokes an hour, the weight of steam used in an hour will be $1.16 \times 224 \times 60 = 15{,}590$ lbs. As the engine is developing 796 I. HP, the amount of steam used per I. HP-hour is $\frac{15590}{796} = 19.58$ lbs. at a pressure of 20.6 lbs. per square inch above the atmosphere.

The same steam was, of course, admitted at the initial pressure; neglecting the heat conducted away from the pipe leading from the boiler, it is also correct to say that 19.58 lbs. of steam at boiler pressure, (90 lbs. in this case) are required to generate one I. HP in the engine under consideration.

All of the above operations may be indicated in a simple formula, as follows:

$$\text{Pounds of water} = \frac{35.47\,(p + 14.7)\,(f + c)}{P}$$

Where p = pressure measured on card.
P = mean pressure used in calculation of I. HP.
f = ratio to whole stroke, of stroke to point d.
c = clearance.

In the case calculated above in detail, $p = 20.6$ lbs., $P = 62.6$ lbs., $f = .926$ and $c = .06$. Therefore,

$$\text{Pounds of water} = \frac{(20.6 + 14.7)\,(.926 + .06)}{62.6}$$

$$= \frac{35.47 \times 35.3 \times .986}{62.6} = 19.72.$$

The slight difference between this result and that obtained by calculation in detail is due to less correctness in the former through dropping parts of decimals, and also through the use of the *mean* piston area in calculating the horse power.

As the method given in this article for calculating steam consumption is only approximate, no account was taken of compression steam in the cylinder when the valve opens. Allowance may be made for this by reducing the clearance coefficient in the ratio of the compression pressure to the initial pressure; that is, if the compression final pressure is half the initial pressure, .03 should be used instead of .06 in the above calculation, since the clearance space would then take only half the amount of steam it would if there were no compression. Similarly, if the compression final pressure is one-fourth the initial pressure, the clearance coefficient would be reduced by .015, and .045 would be used in the formula; if three-fourths the initial pressure, the coefficient would be reduced by .045 and become .015.

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Biographical History of Electricity.

Owing to lack of space, the section of the "Biographical History of Electricity" written for this issue, is held over and will appear in the August number.

LESSONS IN PRACTICAL ELECTRICITY

THE GENERATION OF ELECTROMOTIVE FORCE.

When a man is lifting a weight by hauling on a rope he does not lose sight of the factor which his muscular exertion plays in the operation. The velocity given to the weight, the friction of the sheave, the tension on the material of the rope, or the relation between the velocity of the end of the rope he is pulling on and of the end to which the weight is fastened—none of these makes him lose sight of the fact that the force he generates is the primal cause.

The relation between cause and effect is not always kept so clear in dealing with electricity. We sometimes hear that for a high voltage the armature of a dynamo should have a high resistance, as if the resistance itself affected the E. M. F.; or that certain designs of dynamos give high E. M. F. and certain other designs give large current. The primal function of a dynamo is to generate E. M. F. and therefore in its consideration that should be kept distinct from current and resistance, as the former is an effect whose value may vary with conditions not affecting the generation of E. M. F. Therefore, as remarked before, in the generator give first place to the idea of E. M. F.—in a receiver, to current.

The simplest conception with which to start into the consideration of the generation of E. M. F. is the cutting of what has been called " lines of force," by a conductor. As will be seen later, we need not confine this idea to the case where such lines are cut by a moving conductor, for it may also be applied to cases where lines are added to or subtracted from a circuit by electrical means, as in a transformer, where the primary coil cuts lines into and out of the secondary coil.

The idea of lines of force is illustrated in Figs. 1, 2 and 3. Fig. 1 is a permanent magnet and the dotted lines represent lines of force, which always proceed from the *south* half of the magnet, enter the *north* half, and return through the body of the magnet. Fig. 2 is a representation of the lines of force of a magnet obtained by means of fine iron filings, and shows that the lines are most dense at the poles or ends of the magnet.

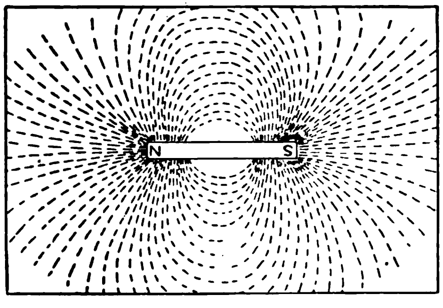


FIG. 1.—LINES OF FORCE OF BAR MAGNET.

Fig. 3 represents the lines of force about a conductor carrying a current. The lines here are concentric to the conductor, and their direction is the same as the direction of motion of the hands of a clock, if we look at the end of the wire in the direction toward which the current is flowing; as shown in Fig. 3, the lines go in the opposite direction to the hands of a watch as they are represented looking against the current. Fig. 4 is a representation of the lines of force about a conductor, obtained by means of fine iron filings, and shows that the lines become less dense as their distance from the wire increases.

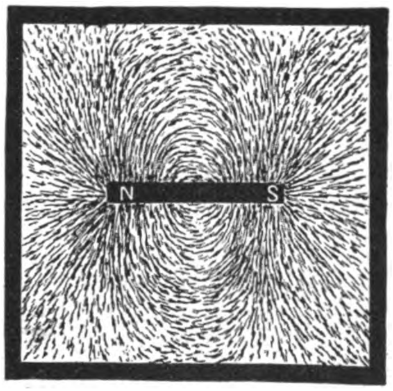


FIG. 2.—LINES OF FORCE OF BAR MAGNET.

If we coil a wire as in Fig. 5, all of the lines of force of the conductor will point in one direction inside the coil, as shown; consequently, the destribution of lines will be the same as in Fig. 1, and the coil (called a solenoid) will act the same as a magnet.

For a given current flowing in the coil of Fig. 5, a certain number of lines of force will result; if a nickel rod is placed inside the coil, there will be a larger number, for the lines will meet with less resistance in nickel than when their path is through air; if iron is substituted, the increase of lines becomes enormous, the magnetic resistance or *reluctance* of air being as much as 2500 times that of iron.

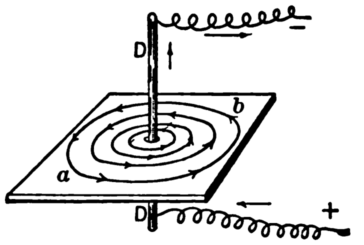


FIG. 3.—LINES OF FORCE OF ELECTRIC CURRENT.

It should be added that the magnetic resistance or reluctance of iron increases as it becomes filled with lines of force, until, when highly magnetized, additional current in the coil will not add more lines of force than would be added if the iron were not present. For example, suppose the current in a coil to be 1 ampere and the number of lines in air and iron 2 and 5000 respectively, or in the proportion of 1 to 2500; then when the current is 100 amperes the lines would be 200 and 18,000 respectively, or in the proportion of 90 to 1, while when the current became 175 amperes these quantities would be 350 and 19,000, or in the proportion of only 1 to 54. Any further increase of current would merely result in adding about the same number of lines as if the iron were not present. In practice, therefore, for each grade of iron there is a point beyond which it would not pay to increase the current in the coil, since the number of lines thereby added would be very small in proportion to the number added for the same increase of current at a lower point. If greater strength is needed, iron of a larger cross section should be used.

In permanent or tempered steel magnets the lines of force always exist, while in solenoids and solenoidal magnets (the latter called electro-magnets) an expenditure of current is required to maintain the lines. It is not practicable, as a rule, however, to use permanent magnets in the generation of E. M. F., for the reason that they are so much more feeble than electro-magnets—an electro-magnet being from 6 to 13 times as strong as a permanent magnet of the same size.

Whenever a conductor forming part of a closed circuit cuts lines of force, an E. M. F. is generated in the conductor and a current will flow in the circuit. Suppose we have, in an electro-magnet in which there is an air gap, as shown, the lines of force generated by the coil, of course, crossing the air gap. Then if the horizontal conductor of the coil is passed through the air gap, an E. M. F. will be generating in it corresponding to the lines of force cut and the time of cutting, and causing a current to flow, say, in the direction indicated by the arrow; if the conductor is withdrawn, it will again cut the lines and generate an E. M. F., but one acting in the opposite direction, causing a current to flow against the arrow.

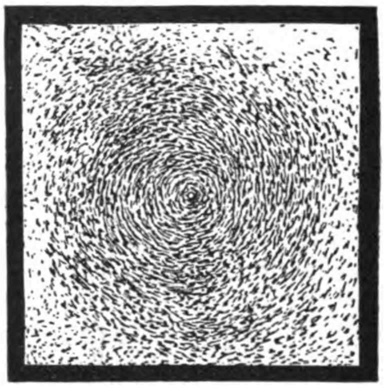


FIG. 4.—LINES OF FORCE OF ELECTRIC CURRENT.

The reader will recognize the similarity of the above case to that of a dynamo with respect to cutting lines. In a dynamo the entire structure aside from the commutator is an arrangement whereby to concentrate lines of force so that they may be cut by conductors, the armature core itself being essentially a part of the magnetic structure. This will be seen by a glance at Figs. 7 and 9. In Fig. 7, showing a Siemens armature, the core bridges the space between the poles, its function being to narrow down to the lowest possible point (owing to its high magnetic resistance) the part of the magnetic circuit

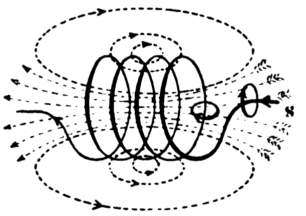


FIG. 5.—LINES OF FORCE OF SOLENOID.

in air which the armature conductors cut, this part being what may be called the "working" portion of the magnetic circuit. The ideal core would be a stationary one with wires revolving about it, as armature iron loss (through reversal of magnetism or hysteresis) would thereby be prevented. In practice the core is revolved with the wires for obvious mechanical reasons. The same remarks apply to the case of Fig. 9, showing a Gramme armature, in which, however, the lines pass through a curved "bridge" instead of straight across as in Fig. 7. Here it will be seen that the wire is idle in the interior of the ring, corresponding to the idle wire on the ends of a Siemens drum. Fig. 8 is a representation of the magnetic field and of a conductor in the gap of a Siemens machine (Fig. 7), obtained by means of iron filings.

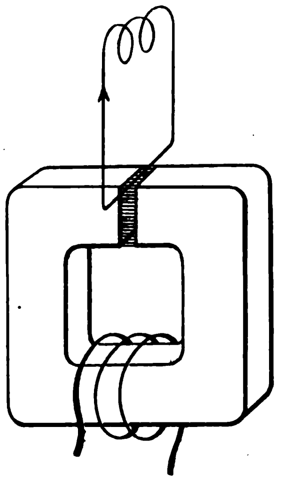


FIG. 6.—CUTTING LINES OF FORCE.

The amount of E. M. F. generated in cutting lines of force depends upon the number of lines cut in a given time, as the number per second; it therefore follows that the density of a field of force may be measured by the E. M. F. generated in cutting that field. The absolute unit of E. M. F. is thus defined as the E. M. F. generated in a conductor which cuts one line of force in one second, and a unit field of force is one containing one line per square centimetre or 6.5 lines per square inch.

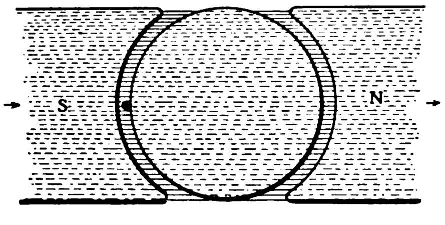


FIG. 7.—LINES OF FORCE, SIEMENS ARMATURE.

In dealing with lines of force, sometimes the entire number present is used in calculations and sometimes the number per square inch or square centimetre. As an illustration, we speak of a piece of iron having a tensile strength of 50,000 lbs. per square inch, and that a certain piece of such iron will require 1,000,000 lbs. of a load to break it, the area in this case being, of course, twenty square inches. Similarly, we speak of cast iron and wrought iron having a working density of 9000 and 15,000 lines of force respectively, per square centimetre (58,500 and 97,500 per square inch), meaning that these materials will economically carry that many lines. In other cases, as in referring to the field in the air gap of a dynamo, the entire number of lines present may be used. In the first case the *density of flux* or density of lines is considered, comparable to the tensile strain per square inch of the bar; in the second case the *total flux* or total number of lines present, is considered, corresponding to the entire weight the bar, whatever its size, will support. The total flux in a dynamo gap may vary from 1,500,000 lines in a bipolar, 100-light dynamo, up to 3,000,000 lines in each of the gaps of a powerful multipolar generator, with density in each case of 3000 lines per square centimetre (19,500 per square inch) which is considered a good figure for an air gap.

As an example of the generation of E. M. F. we will take the case of a conductor cutting lines of force in the earth's magnetic field. As is, of course, known, the earth is in effect a huge magnet; lines of force proceed from the earth north of the magnetic equator and enter the earth south of that equator, being most dense at the magnetic poles, as in the magnet shown in Fig. 2.

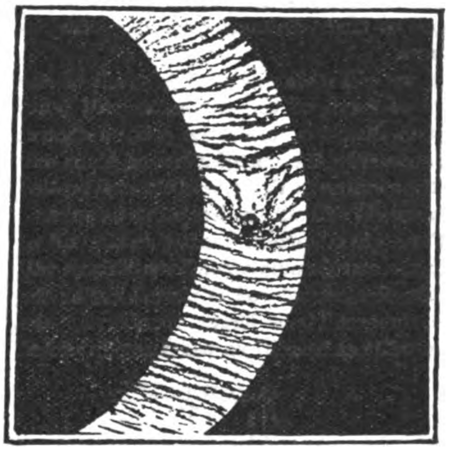


FIG. 8.—LINES OF FORCE, DYNAMO AIR GAP.

It should here be explained that if we call the north seeking pole of a magnet the north pole, then the magnetic pole of the earth north of the equator is a magnetic south pole, since it attracts the north pole of a magnet—dissimilar poles of a magnet attracting and similar poles repelling.

At Chicago the lines of force proceed from the earth at an angle of 72 degs., and to the number of .61 to each square centimetre or 3.96 to each square inch. If a conductor, such as the axle of a railway car, cuts these lines, their full effect will not be obtained on account of their inclination; only the vertical component will be effective in the generation of E. M. F., the value of this component being .579 lines per square centimetre or 3.76 lines per square inch.

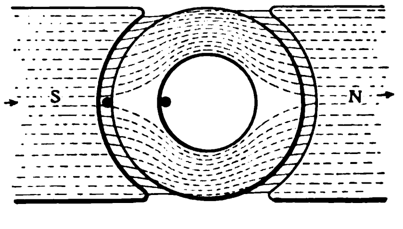


FIG. 9.—LINES OF FORCE, GRAMME ARMATURE.

Referring to Fig. 10, suppose *A B* to be the axle of a railway train running on rails *C E* and *D F*. Suppose further that the train is running at the rate of sixty miles per hour or 1056 ins. per second. If the gauge of the rails is 54½ ins. (4 ft. 8½ ins.), and since there are 3.76 lines to each square inch, when the axle travels over one inch, 3.76 × 54.5 = 204.9 lines will be cut, or 1056 × 204.9 = 216,374 lines per second.

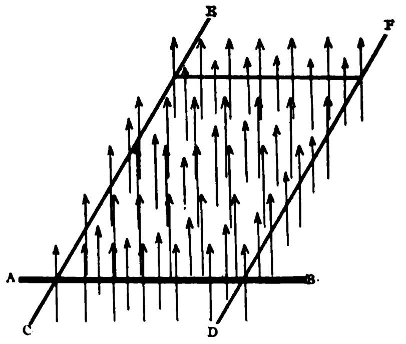


FIG. 10.—LINES OF FORCE IN EARTH'S FIELD.

Now since, as stated before, the electromotive force is measured by the number of lines cut per second, in this case the E. M. F. generated in the axle will be 216,374 absolute units. The practical unit of E. M. F. or the volt, is 100,000,000 times larger than the absolute unit, so that, dividing the former number by the latter, the voltage will be .00216, or 2⅙ millivolts—much greater than a telephone voltage and corresponding to the voltages measured between the terminals of the large shunt employed with a millivoltmeter in the measurement of very large currents.

It will be interesting to obtain an idea of the current thus generated. We will suppose the axle to be over a tie-rod, when the circuit will consist of the axle, half of two wheels, and the tie-rod. For a very rough approximation we may assume that the metallic resistance of this circuit is equivalent to a corresponding one of which each of the parts is three inches in diameter. Then, if the diameter of the wheel is thirty-three inches, the total length of the circuit will be twice the half-diameter of the wheel + twice the gauge, or 142 ins.; referring to a resistance table, we find the resistance of a piece of steel (resistivity = 15.803 microhms) of this length and three inches in diameter to be $\frac{125}{1000000}$ ohm. Dividing the voltage found by this resistance we have seventeen amperes. The resistance of contact at the track, at the tie-rod rail fastenings and at the axle bearings, would be, however, very many times greater than the calculated resistance of the metallic circuit, but nevertheless a measurable quantity of current is generated in the axle of a railway train in motion, the magnetic field of the earth here corresponding exactly to the field in a dynamo air gap, and the axle to the armature wires.

◆

A 3,500,000 Volt Electric Shock.

A daily paper reports that Nikola Tesla has received an electric shock from 3,500,000 volts, with little injury. The skin, the account states, was burnt where the current entered, and a hole made in a shoe where it passed out, but, beyond somewhat of a shaking up, no other ill results were experienced.

Letters from Practical Men

Wanted—A Safe Soft Solder Flux.

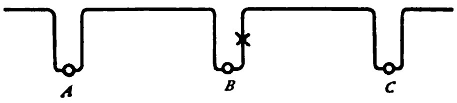
In our business we do a great deal of soldering, and our experience daily impresses upon us the desirability of a flux that is non-corrosive. We have tried all the fluxes that have come to our notice, and while some of them are all that could be desired so far as their action in producing solid joints is concerned, all are open to the objection that any traces of the flux which may be left on the work have a very corrosive action on all metallic objects in the neighborhood and a detrimental action on the insulation. In repair work, especially, the surfaces to be soldered are usually very dirty and very much oxidized, and it is necessary to use a great deal of the flux to make the solder flow properly. Then when the soldering is finished, it is always difficult and sometimes impossible to remove all traces of the flux. The ideal flux would be entirely inert at ordinary temperatures, but under the heat of the soldering operation it would develop sufficient chemical activity to clean the surfaces where it is applied.

For hard soldering, we already have such a flux, namely, borax. What is needed is a flux for soft soldering that will be equally efficient and non-corrosive.

BAECHTOLD & PARKER ELECTRIC CO.

Trouble on an Arc Light Circuit.

A rather puzzling "trouble" once occurred in the writer's experience, and it was so annoying and difficult of location that an account of it is submitted for the benefit of any one who may run afoul of it.



An arc light circuit of fifty lamps tested up "open," and, the lineman having found no trouble perceptible in the wire of the circuit, tests were made to locate a faulty lamp, in which the break was assumed to be. Magneto tests narrowed the suspected stretch to a portion of the circuit between the two farthest apart of three lamps, *A* and *C*, in the sketch; the circuit tested sound beyond lamp *A*, and open toward *B*, while at *C*, the break was also found to be in the direction of *B*. An inspection of lamp *B* failed to detect anything wrong; the lineman examined the wires which connected *B* with the main line, without results, and magneto tests at *B* showed a sound circuit in each direction from the lamp, and a sound circuit *through* the lamp also! (The lamps were suspended from iron wires running diagonally across the street from corner to corner, rope and pulleys being used to lower the lamps for trimming, and flexible stranded wire for connecting with the circuit. The lamp was lowered to the street for testing, of course.) Repeated tests at *A* and *C* invariably indicated a break in the direction of *B*, and tests at *B* showed both circuit and lamp to be sound; another lamp was substituted at *B*, without additional developments. Finally some one awoke to the fact that raising and lowering the lamp might affect the break if it was in the flexible connecting wires at *B*, and tests at *A* and *C* were made with the lamp at *B* lowered; a sound circuit was the result, and as soon as *B* was raised about half way the break reappeared. It was found to be due presumably to a drop of acid; one of the connecting wires was eaten in two, the strands of the cable being pointed at the break; the insulation was not damaged sufficiently to break, and presented an apparently intact condition on the outside. The break was half way between the lamp and the pole-top, and when the lamp was lowered, the wire was straightened so that the pointed ends touched; when it was raised the wire sagged and opened the circuit.

SUPERINTENDENT.

Cutting Action of Steam.

Do you or any of your correspondents have a theory of what causes a fine jet of steam to have a cutting action? I have been much troubled with the grooving on globe valve seats, and I find that a leak in the steam piping system will quickly cut larger. In one case, I knew of a Jenkin brass globe valve, in which the disk and spindle had entirely disappeared, and the end of the spindle looked as if a rat had gnawed it off. The valve was no more obstruction to the steam than a pipe coupling, and the only thing that called it to our attention, was the fact that coal consumption was suddenly increased, caused by the steam blowing out through this valve to the sewer.

The leak was sought for vainly, for a whole half-day. Finally one of the helpers tightened this valve, which he was sure was shut, and the spindle turned around in his hand and in an instant more blew out. No trace of the disk could be found, but the seat was badly cut. Now was this caused by an acid in the feedwater, or does not steam have a cutting action?

N. R. RIPLEY.

Polarity Tester.

I note with interest the reply in the June issue to the query of "L. T." concerning the determination of the positive pole of a dynamo, and take the liberty of suggesting the following "polarity test" which I have found satisfactory in testing circuits of from 110 to 6250 volts. As it can be applied in two or three minutes, it has an advantage over the more complicated magnetic devices.

In one fluid ounce of glycerine dissolve fifteen grains of *red* iodide of mercury and twenty grains of iodide of potassium. Dampen a piece of unglazed white paper with the solution, and apply it to the poles (about one inch apart for 110 volts—higher voltage in proportion) for about one minute, when the spot touched by the negative pole will turn yellow.

This test can be used on any part of the circuit from which leads can be taken and without placing any additional resistance in series. I have tested an arc machine with the margin of a newspaper long enough to reach across binding posts; of course, the paper must be dampened its entire length.

The solution is harmless and will keep in any temperature, and the materials can be obtained of any druggist at small cost.

J. H. KEIM, Jr.

The Selection of Iron for Dynamos.

Your editorial of last month referring to an instance of excessive hysteresis losses in a motor armature, is especially pertinent at this time, as the following facts will show. For years past there has been a strong tendency to substitute steel of various grades for iron in all places and for all uses. This is owing to improvements in processes for making steel, which have made some grades of steel actually cheaper, pound for pound, than a high grade of iron. Moreover, for most mechanical purposes, steel (of the proper grade) is so much better than iron, that it is cheaper even at a somewhat higher price per pound. Iron track rails are now an anachronism, and some leading manufacturers announce in their catalogues that they no longer roll structural forms out of iron, steel having superseded iron, so far as high buildings are concerned.

This gradual elimination of iron, though for the most part an unqualified benefit, renders it very necessary for the electrician to carefully examine what he buys. The magnetic qualities of different samples of steel may differ widely, while their mechanical qualities may agree so well that it is a matter of indifference for mechanical purposes which is used. The degree of perfection to which steel casting has been brought renders it possible to cast field magnets for dynamo machines which are in all respects superior to cast iron, and even in some degree to the common grades of wrought iron, yet the electrician who expects to get satisfactory field magnet castings from any steel founder, will be sadly disappointed.

More particularly is it necessary to have iron (or steel if it be used) for armatures, exactly right, as the saturation is generally higher in armatures, besides which the rapid reversal of polarity renders the effects of hysteresis more serious, although the presence of hysteresis is by no means a matter of indifference in the field magnets of constant potential machines. Hysteresis means that the saturation curves for rising and falling magnetizing forces are different, and therefore, where the difference is considerable, a machine can not be compounded to regulate accurately for change of load.

But to return to the armature; pursuant to the general tendency, the sheet iron of commerce, including the "pure charcoal iron" in many instances, has become steel. Even tin plates are now made of steel, and the only certain way to get genuine charcoal iron is by special order from reliable manufacturers. Some dynamo builders use sheet steel for their armatures and find it satisfactory, but the general run of sheet steel on the market is entirely unfit for the purpose. Some kinds of steel, owing to the process of manufacture, are much more liable to contain notable quantities of manganese than is iron, and of all known substances manganese is the most detrimental to the magnetic qualities of iron. As is well known, not only does it decrease the permeability of the iron, but it also increases the hysteresis enormously.

TOWNSEND WOLCOTT.

ELECTRICAL CATECHISM

19. How can one tell the allowable current from the size of the armature wire?

Determine the size of wire and the total number of circuits among which the armature current is divided. Determine also whether each path consists of a single wire or of two or more wound as one. From a wire table, find the number of "circular mils" in the wire used, multiply by the total number of wires in parallel, and divide by 600. The result is about the number of amperes the armature can probably deliver without excessive heating.

20. Why do you divide by 600?

Because experience shows that 600 circular mils per ampere is about the smallest size of wire allowable. This figure varies in different cases from 325 to 650.

21. How can one tell the number of paths for the current in an armature?

In a two-pole machine the current divides into two equal parts, each side carrying half. In multipolar machines having an even number of commutator segments, the number of paths in the armature is the same as the number of poles in the field. If the number of commutator segments is an odd number, such as 95 or 101, the armature has a two-path winding. Alternator armatures have either a single or double path, the double path being indicated where the leads to the collecting rings come from opposite sides of the armature.

22. In starting a shunt dynamo, should the main line switch be closed before the machine is up to voltage or after?

If the machine is working on the same circuits with other machines or with a storage battery, it is, of course, necessary to make the voltage of the machine equal to that on the line before connecting it in. If the machine works alone, the switch may be closed either before or after the voltage comes up. The load is thrown on suddenly if the switch is closed after the machine is up, thus causing a strain on the belt, and possibly drawing water over into the engine cylinder. On the other hand, if the switch is closed before the voltage of the machine has come up, the load is picked up gradually, but the machine may be slow or even refuse to pick up at all.

23. Why does a shunt machine pick up more slowly if the main switch is closed first?

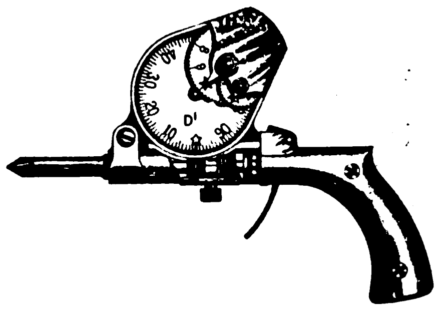
Because the resistance of the main line is so much less than that of the field that the small initial E. M. F. due to the residual magnetism causes a much larger current in the armature than in the shunt field. If this is too large, the cross and back magnetizing force of the armature weakens the field more than the initial field current strengthens it, and so the machine cannot build up.

24. If a shunt dynamo will not pick up, what is likely to be the trouble?

The speed may be too low; the resistance of the external circuit may be too small; the brushes may not be in the proper position; some of the electrical connections in the dynamo may be loose, broken or improperly made; the field may have lost its residual magnetism.

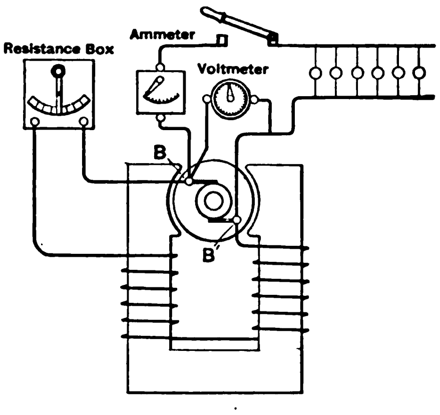
25. How can one tell if the speed is too low?

The proper speed is usually stamped on the name plate of the machine or on one end of the armature shaft. If not marked on the machine, it may be found in the catalogue of the manufacturer. Otherwise it may be estimated as indicated in *14.* (AMERICAN ELECTRICIAN, June, '96, p. 68) The actual speed of the armature may be measured by a revolution counter and watch, or by a tachometer, the sharp end of the spindle of the instrument being held against the end of the armature shaft so that the two revolve at the same speed. Sometimes a convenient way is to count the engine speed by one's fingers, as suggested in *Electrical Industries*, March, 1895, page 78, and then get the dynamo speed by multiplying the engine speed by the ratio of diameters of engine and dynamo pulleys.



26. How can one tell whether the brushes are in the proper positions?

Most shunt dynamos, except Edison machines, should have the brushes touch the commutator at points opposite the space between the pole pieces as indicated in the figure. Care should be taken that the brushes make good electrical contact with the commutator. Sometimes the armature has so much end play that the brushes make poor contact, a temporary remedy for this being to hold a stick against one end of the armature shaft so as to stop end play until the machine has picked up. Care should be taken also that the springs press the brushes firmly but flexibly against the commutator.



27. How are the brushes of an Edison dynamo placed?

The brushes of an Edison dynamo are placed almost opposite the middle points of the pole pieces. This is because the commutators are practically set around one quarter turn, so that a given coil of the armature is not connected to the commutator bar directly opposite, but to one ninety degrees ahead. This is simply to bring the brushes into a more convenient position.

28. Should the brushes of a dynamo be in the same position with a large load as with a small load.

Some machines are so designed that no shifting of the brushes is necessary. Usually the brushes must be moved forward, in the direction the armature rotates, as the load becomes larger. This is to reduce the sparking.

29. How can one tell if the resistance of the external circuit is too low?

The machine will build up its voltage if the main circuit is open, as indicated in Fig. 26; but will not build up if the main line is closed. The reasons are given in *22* and *23*.

30. What electrical connections in the shunt dynamo are liable to become loose or broken?

The connecting screws at binding posts and elsewhere are liable to jar loose, and should, therefore, be tried about once a week with a screw-driver or wrench. The terminals of the fine wire of the shunt field coils of some machines are liable to be easily broken. Sometimes the connections between the armature wires and commutator become loose or broken. A frequent source of trouble is poor contact between the arm and segments of the regulating rheostat; this can be tested while the machine is running, but not working, by touching the ends of a short wire to the terminals leading to the rheostat so as to short-circuit it for a moment; if the trouble is in the rheostat, the machine will come up to voltage quickly when the rheostat is thus cut out. Sometimes the ends of the brushes get coated over with oil and dirt so as to make poor contact. In some machines oil is liable to get into the brush holder and connections, and so increase the resistance of the contact between the different parts. Trouble is less likely to occur from poor contacts if the machine is kept clean and all connections tight

31. How are improper connections liable to occur in a dynamo?

When the machine is first set up or after repairs, the connections between the armature and the fields are liable to get reversed; the field coils may be connected so as to oppose rather than assist each other; the machine may be short-circuited. Short circuits are also liable to occur by accident or carelessness after the machine has been running all right.

Note. Question 11. in the June number, through a printer's transposition, read "How does the shunt of a field dynamo pick up?" instead, as written, How does the field of a shunt dynamo pick up?

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Depreciation of Electric Light Plants.—In a recent address, Mr. M. J. Francisco, ex-president of the National Electric Light Association, gave some figures as to the depreciation of electric light plants owned by municipalities. Wabash, Ind., paid $18,000 for an outfit, and after six years sold it for $3000. Xenia, O., paid $35,000 for a plant and after eight years sold it for $10,000. Moline, Ill., paid $15,000, and after four years sold it for $8000. Oxford, O., paid $25,000 for a plant, and now they say they can replace it for $12,000. Michigan City, Ind., paid $10,000 for a plant and sold it for $2500.

QUERIES AND ANSWERS

Can a straight wire moving in a magnetic field have any current set up in it? M. S. G.

Yes, if the magnetic field is one of varying force with respect to the length of the wire. In this case the distribution of potential along the wire will vary, which variations will cause current to flow.

Can a coil be cut out of a T.-H. F 30 motor armature without disabling the motor? S. S.

In an emergency a defective coil can be cut out and a conducting wedge driven between its two terminal commutator bars. If necessary in order to return to the car barn, several coils may thus be cut out, but this should only be done in an emergency. One or both ends of the defective coil should, of course, be disconnected.

1. Is hard fibre affected by paraffine oil? 2. What cement is used with this material? 3. Can it be softened so that a "bead" may be worked on the end of a tube? I ask this information in order to know if hard fibre is suitable for induction coils. M. L. S.

1. Hard fibre is unaffected by submersion in paraffine oil, and will remain indefinitely in the oil without injury. 2. There is no cement that will hold fibre with absolute security. 3. Fibre can be softened by soaking in water. It will swell slightly, but upon drying will be as hard and of the same size and shape as before.

Does any current flow in an alternating current open circuit? M. S. G.

Yes, an amount due to the capacity of that circuit. The wires act as a condenser, and as the voltage rises and falls, they are charged and discharged in the same manner as a condenser. The current passing supplies the static charge, and therefore is greatest at the dynamo binding posts and becomes zero at the end of the line. The mean current flowing is, however, extremely small, except in the case of concentric conductors. Besides, inductance in the circuit tends to neutralize this capacity current.

What size of wire is best for the secondary of induction coils? Different authorities give from No. 30 to No. 40. A. T.

The size of wire depends upon the purpose for which the induction coil is to be used. If intended merely to get a long spark, No. 40 wire will be the better, as a greater E. M. F. may be obtained from the same space occupied than with a larger wire. If, on the other hand, a "fat" spark is required, the wire should be correspondingly large. For vacuum discharges, No. 30 is much better than No. 40, though with the former the dimensions of the coil is greater.

How are storage batteries connected for street railway use? E. J. B.

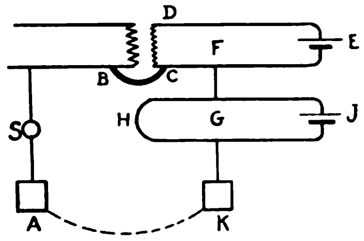
The battery is connected between the dynamo terminal (or between the line and ground), usually, in series with a booster (dynamotor). The dynamo end of the booster is of sufficient current capacity to carry the maximum storage battery current. Its fields are excited with the main line current, and when this current is light, the booster voltage is low and the line voltage, overpowering the combined booster and battery voltage, charges the battery; when the line current is heavy, the booster voltage rises, and the combined booster and battery E. M. F. becomes sufficient to force current into the line. The same result can be accomplished by automatically varying the number of cells between the terminals.

How much stronger is an electro-magnet than a permanent magnet? S. L. C.

The number of lines of force per square inch carried by a magnet is a measure of its strength. In permanent magnets the number of lines varies from 10,000 to 16 000 per square inch, the latter figure having been obtained with Marchal steel. With ordinary commercial steel, the strength may fall considerably below 10,000 lines. The strength of an electro-magnet varies, of course, with the exciting current and the magnetic quality of the iron core, but good soft iron magnetized to its usual working limit carries 100,000 lines per square inch. With some grades of iron and a very high magnetization, this figure may attain over 130,000 lines. If, then, we have two horseshoe magnets of identical shape, but one made of permanent steel and the other of good soft iron wound with a coil and supplied with the proper current, the latter will lift from 6 to 10 times as much as the former.

What causes a transformer to deliver the voltage of a grounded arc circuit into a building? J. T. L.

Such an occurrence would appear to be very unusual. It may happen, however, under the following circumstances: 1. The arc circuit is grounded; 2. One leg of the arc circuit is crossed on one leg of the primary; this cross may occur through the arc line being grounded on a transformer in which the primary is grounded on the case. 3. The primary is grounded on the secondary in the transformer, either directly or through the transformer case. While this will deliver the arc voltage into a house, it will also deliver the primary alternating voltage. This is made plain from the accompanying sketch:

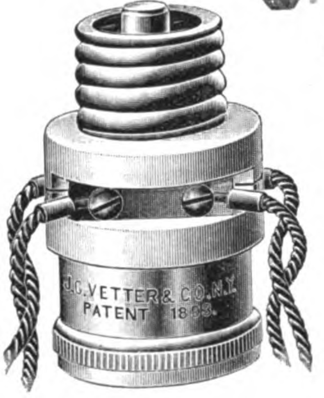


A person at *S* will experience, by touching, for example the part of a base of a lamp which projects from a socket: 1. The arc voltage through the circuit *A K J G F C B*; 2. The alternating voltage through the circuit *A K J* and *H F E D C B*. A source of danger in alternating lighting is illustrated by the upper sketch, if we suppose the alternating circuit directly grounded at *F*, instead of indirectly grounded through the arc circuit. To guard against this danger, the manager of a certain large alternating station grounded the secondary in his residence through a device that would ring a bell if the conditions above referred to should arise.

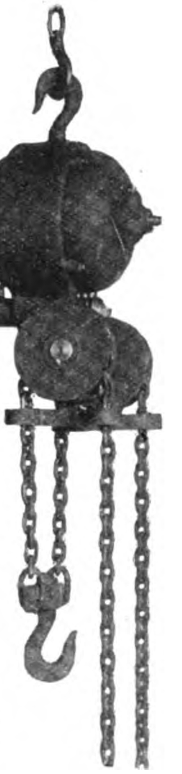
NEW APPARATUS AND APPLIANCES.

THE LOUNSBURY ELECTRIC CHAIN HOIST.

In the chain hoist shown in the accompanying illustration, the motor frame, countershaft bearing and chain sheave are in one piece of solid steel casting of high tensile strength. The motor, it will be observed, is thoroughly encased so as to be absolutely moisture and dust proof, and the bearings are self oiling, requiring attention only about once a month. The worm gearing is also enclosed and runs in a bath of oil; the thrust of the worm is taken by hardened steel ball bearings. The hoist is suspended from an ordinary hook, as seen in the illustration; wires connected with the motor run to a reversing switch placed at any convenient point in the neighborhood of the hoist, at which there is also located an ordinary rheostat. By means of these the operator controls the current so as to give the motor any desired speed. With the smallest hoist made, the control is so efficient that a weight of 2000 lbs., can be stopped when raised or lowered within a small fraction of an inch. A raw-hide pinion on the motor shaft makes the gearing noiseless in operation. The manufacturers of the hoist, which is made in three sizes having a lifting capacity of 2000 lbs., 3500 lbs. and 5000 lbs., respectively, are Lounsbury & Company, 225 West Twelfth Street, Chicago, Ill.


J.C.VETTER & CO.N.Y.
PATENT 1893.

VETTER CURRENT-TAP.



LOUNSBURY HOIST.

A CURRENT-TAP FITTING.

The fitting illustrated herewith will be recognized by electricians as a much needed addition to the list of incandescent lamp fittings. As will be seen, it consists of a plug adapted to screw into a lamp socket; the displaced lamp is screwed into the socket end of the plug, and current may be tapped from two pairs of connections on the side of the plug for any desired purpose.

Many offices are supplied with only one or two single wall brackets, and the use of a drop light or fan motor generally means the loss of the lamp, through its being displaced by a socket plug. The tap illustrated, however, leaves the lamp where it is, and carries the current to any desired point; thus, from a single wall bracket there can be obtained by means of the tap, a wall light, a drop light, and current for a fan motor. It is particularly convenient for the sick room, and useful in factories or workrooms, where a good light is needed directly over an object somewhat removed from the lamp bracket, without losing the light from the lamp bracket itself. The physician who has the incandescent current in his office can, by means of the current tap, easily be provided with a portable hand lamp for diagnostic illumination.

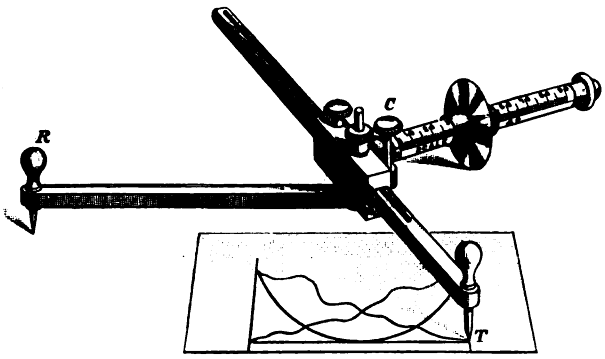
The fitting, which is known as the Vetter current tap, is made by J. C. Vetter & Company, 140 East Twenty-third Street, New York.

INDICATOR CARD PLANIMETER.

The laborious and inaccurate method of calculating indicator cards by means of ordinates has been entirely discarded in favor of the planimeter aboard marine vessels and elsewhere where cards are taken at frequent intervals. Many engineers who now neglect their indicator on account of the labor of working up cards by the old method, if possessed of a planimeter enabling a card to be accurately calculated in a few minutes by a mere mechanical manipulation, would find a bothersome task so lightened that they would no longer find excuses to put it aside.

The planimeter we illustrate has been specially devised for indicator card work and gives the mean pressure direct, each instrument having scales corresponding to twelve springs ranging from eight pounds to eighty pounds. The wheel has a knife edge and is free to move on its shaft, so that there can be no slipping on the surface upon which it travels, giving the same results when used upon the roughest table as upon the finest paper. Instead of the wheel sliding on its periphery, it slides on its bearing, which is a glass shaft practically frictionless. Inside the shaft is placed the scale, printed on specially prepared paper so that the greatest contrast and legibility may be secured; the ends of the shaft are hermetically sealed, thus preserving the scale from any atmospheric deterioration.

This instrument, which is known as the Lippincott planimeter, is made by the Hine & Robertson Company, 86 Cortlandt Street, New York.



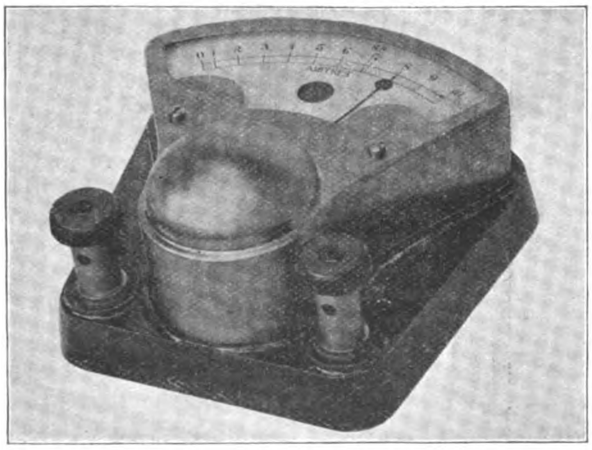
INDICATOR PLANIMETER.

THOMSON ARC CIRCUIT AMMETER.

The standard instruments which the General Electric Company has lately placed upon the market include the Thomson arc circuit ammeter, which is illustrated herewith. This is a high grade instrument for switchboard purposes and is mounted upon a black enameled metal base, with the cover, binding posts and screws of bright nickel. It measures over all 8 ins. × 8 ins.

The qualities claimed for this instrument are its high degree of accuracy, its permanent reliability for service, together with an absolute dead beat movement of the pointe The scale is long and may be clearly read from a distance. One ammeter may be used for either half or full arc circuit, the divisions being wide and the calibration marked for both services. Permanency of calibration is obtained by the elimination from the instrument of any parts liable to change. Each ammeter is provided with a self-contained polarity indicator consisting of two signals — the white showing under normal conditions, the red on reversal, the latter remaining in sight until the current passes through the instrument in the proper direction.

The ammeter may be used for front or for back connections, connection posts and studs being furnished as conditions require.

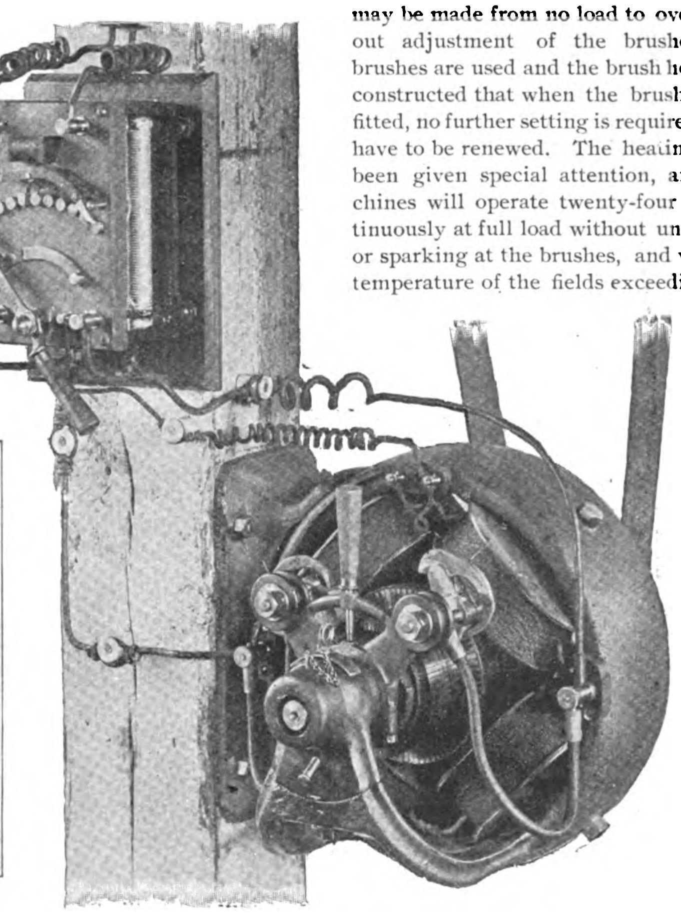


ARC CIRCUIT AMMETER.

NEW TYPE OF MULTIPOLAR MOTORS AND DYNAMOS.

The accompanying illustration shows a recent type of multipolar motor with a frame designed to admit of the machine being operated in any position. By means of the adjustable base used, the motor may be bolted to the wall, ceiling or in any position where most convenient, or where the space occupied is of no consequence.

This type of machine is constructed with self-oiling bearings, steel pole pieces with pole shoes, and iron-clad toothed armature with interchangeable coils. The armature is so designed and the distribution of the magnetic field is such, that the machine, it is claimed, is absolutely sparkless, and changes may be made from no load to overload without adjustment of the brushes. Carbon brushes are used and the brush holders are so constructed that when the brushes are once fitted, no further setting is required until they have to be renewed. The heating limit has been given special attention, and the machines will operate twenty-four hours continuously at full load without undue heating or sparking at the brushes, and without the temperature of the fields exceeding 44 degs. F., and the armature 75 degs. F., above that of the surrounding air. They are built in a number of sizes, from ½ to 5 HP and for both slow and medium speed. The dynamos of the same type are of a capacity from 9 to 80



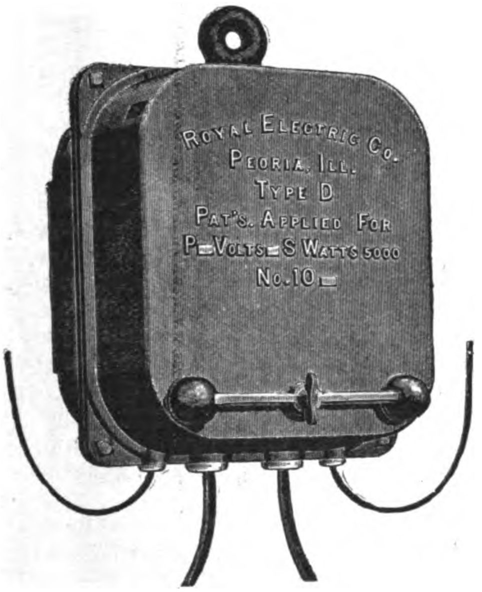
MULTIPOLAR MOTOR.

lights. The machine illustrated is of 2-HP capacity and runs at 1200 r. p. m. The type of automatic starting rheostat used with the motors is shown in the cut mounted above the motor.

The machines are known as type "D," and manufactured by the E. & C. Electric Company, Cleveland, O.

THE ROYAL TRANSFORMER.

The transformer illustrated herewith, of the Royal Electric type, is built for 1000 and 2000-volt circuits and 100 and 50-volt secondaries, and for a frequency of 16,000 alternations (133 periods per second). The core has a small magnetic circuit, and the winding has ample cross-section, so that the regulation is good and the internal losses small. The coils are heavily insulated from each other and from the core, and carefully built. On account of the frequent call for fuses located in the transformer, besides a separate fuse block, fuse plugs are provided in the transformer boxes, extending from the front to the back of the box. The fuse itself is about four inches in length. The fuse plug is provided with an insulating handle which extends to the outside of the box. It is, however, protected in a waterproof manner by the two spheres shown on the transformer front, which are held firmly above the handles by the thumb screw, located centrally between them. This screw, which is enlarged at the end so that it cannot be bodily removed from the box, will allow, when loosened, the spheres to be turned around it as the axis, and thus give access to the fuse plugs. These latter are removed without incurring the slightest danger from electric shock.



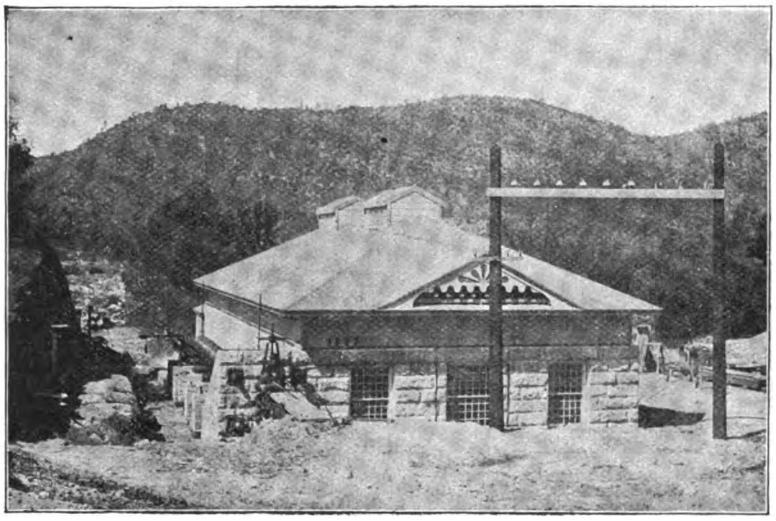
ROYAL TRANSFORMER.

The above transformer is manufactured by the Royal Electric Company, Peoria, Ill., whose alternator was illustrated in the June issue.

A THIRTY-FIVE MILE ELECTRICAL POWER TRANSMISSION PLANT.

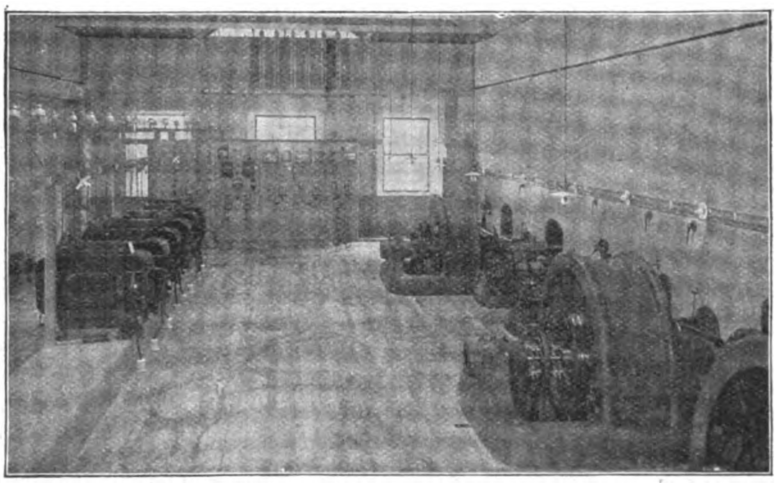
One of the most interesting electrical transmission plants in the United States has recently been completed at Fresno, Cal. The generators are run by Pelton wheels supplied with water under the enormous head of 1600 ft., the water being led to the power house by a steel pipe line 4100 ft. long, and 22 ins. in diameter at the lower end.

The water wheels are of the impulse type, each capable of developing 500 HP at 600 r. p. m. under a working head of 1400 ft., corresponding to a pressure of 610 lbs. per square inch. Separate wheels are provided for the exciters.



POWER HOUSE—FRESNO PLANT.

The electric plant consists of three General Electric three-phased generators, each of 350 KW capacity at a speed of 600 revolutions. The armatures are directly connected to the water wheels by insulated flange couplings. The exciters used are of the slow speed multipolar type. The current from the generators is delivered to six 125-KW step-up transformers of the air blast type, with secondaries wound for 11,200 volts, to which pressure the current for the transmission line is raised. From the transformers, the current passes to a polished marble switchboard, consisting of six panels, three of which are generator panels, one an exciter panel and the other two for operating the combination of the six transformers.



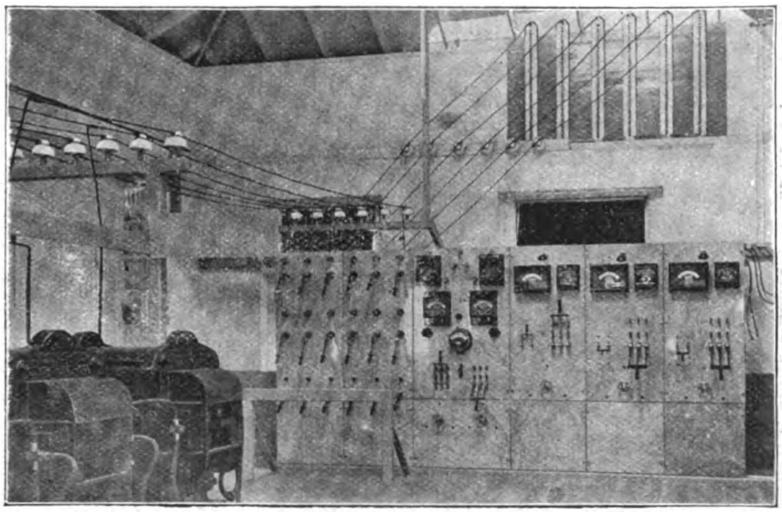
GENERATOR ROOM—FRESNO PLANT.

through wheat fields and vineyards and follows a special right-of-way and wagon road for the entire distance. The total length of the transmission line from the power house to the sub-station is little short of 35 miles, and is thus the longest commercial electric power transmission in the world. The line is strung on special high tension porcelain insulators, which were tested under 27,000 volts alternating before use. The poles are of square redwood, 35 ft. long, set 6 ft. into the ground and fitted with three heavy cross arms and one small cross arm for telephone wires.

The sub-station at Fresno is almost in the center of the business portion of the city, and is a brick structure 55 ft. × 45 ft. The high pressure circuits entering the house are brought to nine step-down transformers, also of the air blast type. Three of these are of 125-KW capacity, and reduce the pressure to 200 volts; three of 75-KW capacity with secondaries of a 1000 volts; and three are of

The 11,200-volt circuit, consisting of six bare copper wires, crosses the San Joaquin River with a span of 275 ft. wide, and is then led up the mountain for a distance of about 2000 ft. The line continues for about ten miles through a rolling, hilly country, is easy of access and at all times below the snow line; the rest of the distance the line runs over a flat country, and near Fresno passes 40-KW capacity, reducing the pressure to 3000 volts. In addition to these transformers, the station also contains two 80-light Brush arc machines directly driven by two 60-HP, three-phased induction motors.

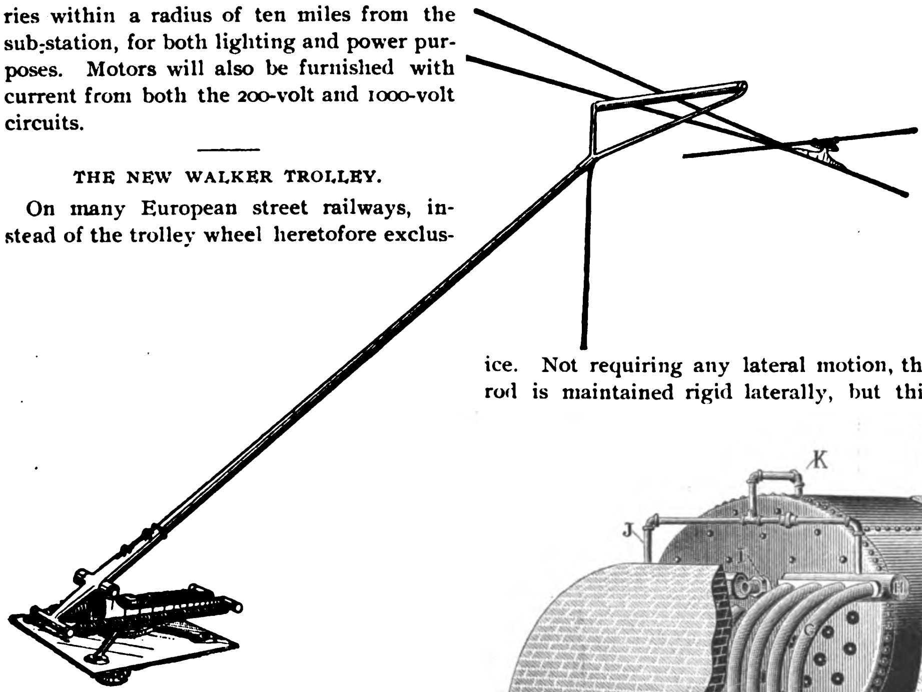
The system of distribution from the sub-station is divided up into three networks. The first is a 200-volt, four-wire, low-tension network, which covers the business portion of the town, and has an initial capacity of 6000 16-CP incandescent lamps. The second is a 1000-volt, three-phased system covering the residence districts of the town, and having an initial capacity of 4000 16-CP incandescent lamps. The third is a 3000-volt, three-phased circuit designed to furnish current to the numerous vineyards and wineries within a radius of ten miles from the sub-station, for both lighting and power purposes. Motors will also be furnished with current from both the 200-volt and 1000-volt circuits.



SWITCHBOARD—FRESNO PLANT.

THE NEW WALKER TROLLEY.

On many European street railways, instead of the trolley wheel heretofore exclusively used in this country, a long horizontal cylinder mounted on the end of the trolley arm has been preferred, among others Dr. John Hopkinson, the eminent English authority advocating this form. Recently the Walker Company, of Cleveland, O., has adopted this type of trolley contact, and will hereafter employ it exclusively on its equipments.



NEW WALKER TROLLEY.

The illustration very clearly shows the principle of the trolley. The long horizontal contact cylinder is mounted on ball bearings, thus obviating provision for lubrication and the attendant evils accompanying the use of oil. The cylinder is made of hard steel sheathed with a coating to insure the best contact. The most notable advantage of this form of trolley contact, however, is that the cylinder or roller cannot leave the trolley wire, and no provision for special switches is required. The first named advantage is of particular weight where roads have heavy grades, or where there is a high-speed service. Not requiring any lateral motion, the rod is maintained rigid laterally, but this does not interfere with the freedom of turning the trolley around when it is necessary to reverse the motion of the car. By simply pulling down the trolley arm, a suitable mechanism unlatches the support at the base, thus allowing it to be swung around; when brought to its reversed position, it is again latched.

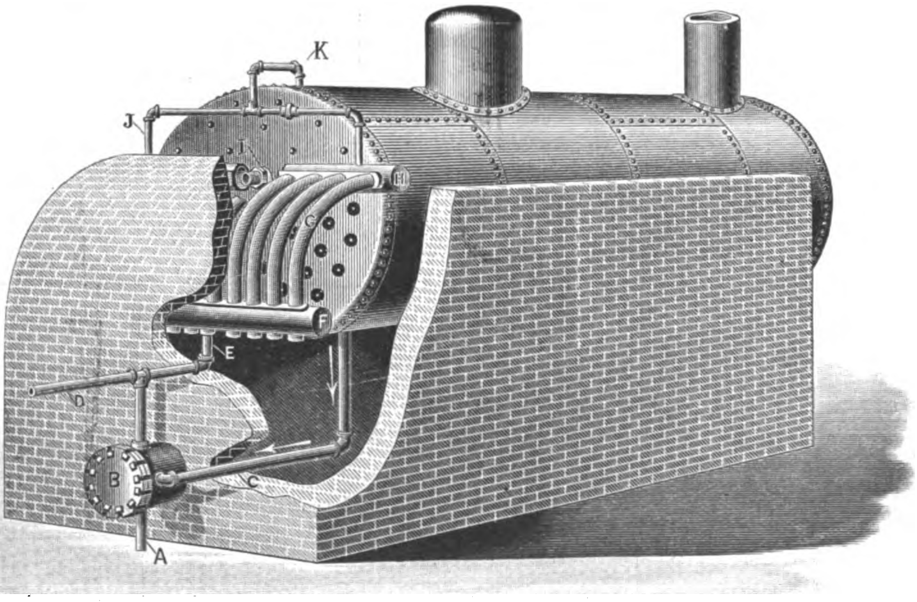
ECONOMIZER FOR RETURN TUBULAR BOILERS.

The boiler attachment shown in the accompanying illustration is designed to utilize the intense heat that with the ordinary boiler setting is radiated and absorbed by the heavy brick work, in time cracking open the walls and arch and thus permitting cold air to rush in to cool the furnace gases and spoil the draught. The attachment also serves as a feed-water heater, and by adding to the heating surface further improves economy of operation.

The attachment consists of headers connected with tubing, the latter, *G*, bent in the form of an arch as shown in the illustration. The ends of the upper headers, *H*, rest upon the side walls, and the lower header, *F*, is supported by the rear wall. The bottom of the upper header is set even with the top of the upper course of flues of the boiler, and the header connected with the boiler by a pipe, *I*, passing through the boiler head just below the low water line.

A mud trap, *B*, is set in the furnace wall below the arch support or heater, and a pipe connection, *C*, made from the side to the bottom of the boiler, and another, *E*, from the top to the bottom header of the heater; a blow-off pipe leads from the bottom of the trap. The feed-water pipe, *D*, is connected to the last named pipe. The small pipe, *J*, connecting the top headers with the boiler steam space is an equalizer pipe. An interior pipe discharges the water a little forward of the boiler.

The construction allows the water to always flow instantly to the hottest point, and the opening from the upper header is ample in size to discharge the volume of rapidly rising water and steam. It is claimed that the attachment makes the arch and rear walls as tight as a drum head, and that the constant circulation of water through the heater absorbing the heat, the mortar with which the



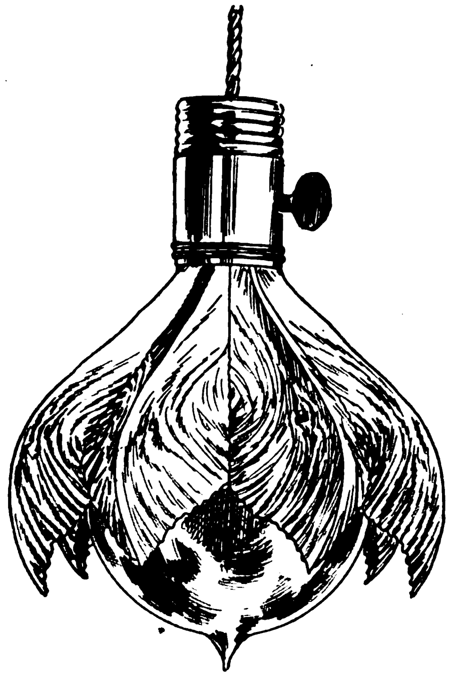
C. & B. BOILER ATTACHMENT.

bricks are set does not even crack. Consequently there is never a leaky tube, a cracked wall, bad draught or burned out arch to repair. The water in the heater being in small quantity, becomes heated much more rapidly than in the boiler, causing the water and steam to rise rapidly and set up a circulation from the bottom of the boiler through the attachment back into the boiler. No deposit forms in the boiler, as by gravity and circulation it is carried down the connecting pipe into the mud trap, from which it is blown out, with the loss of a small fraction of the amount of water lost by the usual mode of "blowing out," thus further increasing economy of water and heat. With ordinary constant feed the economizer more than heats the water to the steam point.

The boiler attachment described is made by the C. & B. Attachment Company, 10 Warren Street, New York.

PAPER LAMP SHADES.

A paper shade for incandescent lamps has recently been placed upon the market, designed for temporary use on occasions when ornamental decoration is an object, and also for permanent employment in order to protect lamp globes from dust, dirt and flies.



PAPER LAMP SHADE.

The shade, which is shown in the accompanying illustration, is of handsome shape and made in eight different colors; when in place on a lamp it has the appearance of a porcelain lily. Their cheapness and attractive appearance commend them, as well their simplicity of application. The shades are made by A. A. McCreary, 136 Liberty Street, New York.

A ROCKY MOUNTAIN TRANSMISSION PLANT.

One of the first power transmission plants installed in this country was that of the Virginius mines of the Caroline Mining Company at Ouray, Colo., and its operation since 1891 has been continuous.

The Virginius mines are situated near the summit of Mount Sneffles, in a region of perpetual snow, some 12,700 ft. above the level of the sea, or 5000 ft. above the timber line. They consist of some mines rich enough to repay mining under the most adverse circumstances, and of others containing a low grade of ore, which could not be mined profitably without cheap power. This power is derived from the water of the Red Canon Creek, which is brought through a pipe line 4000 ft. long to Pelton wheels which drive General Electric bipolar dynamos, the working head being 485 ft. The transmission line passes first through dense timber, then over rocks and chasms and heavy snow drifts until it reaches the mine four miles away from the power house. The current is direct and the voltage 800 volts. The motors drive hoists, pumps, blowers, stamping mills, drills, and an order has recently been given the General Electric Company, which put in the original plant, for an 800-volt two-motor mining locomotive for hauling the silver ore laden wagons in the mine.

Access to the mines in winter is impossible, and in summer extremely difficult, and before the adoption of electricity the Caroline Mining Company was paying $18 a ton for its fuel, the daily expense of this item amounting to over $100 a day. The amount of power now used is double that formerly supplied by the superseded steam plant, and the saving probably more than repays the cost of the plant every year. Mr. A. E. Reynolds, the manager, recently said "Probably the most forcible way in which I can explain the advantage of this plant is to state that without it, it would be impossible to operate the mines, as our expenses would be prohibitory."

AN ELECTRIC POWER FACTORY.

The new factory of Tiffany & Company at Forest Hills, N. J., will be operated entirely by electricity, not a steam-driven machine to be employed beyond the limits of the power house. The present factory and force at 53 Prince Street, New York, will be moved out as soon as the electrical apparatus is installed. The electrical plant will consist of two 125-HP, 250-volt General Electric dynamos, which will furnish current to more than twenty motors scattered through the building. This will be 300 ft. long in front, and will have three wings, each 100 ft. long, extending back of the main building. Of these motors some will be attached directly to the machines, and will drive a number of belts from a shaft. The electrical system of power distribution, in the Tiffany factory, has been adopted as more economical and desirable than any other known method, and only after careful calculation and comparison with the results obtainable from a distribution of power to shafting by belts from steam engines.

HIGH AND LOW VOLTAGE.

During a recent discussion in England on 220-volt lamps, one of the speakers interested in the alternating current system, said it was rather amusing that the low-pressure men had now to confess that high pressure was right. He considered, however, that low-pressure men were attempting to give high pressure upon a perfectly inflexible system.

PERSONAL.

Mr. Ludwig Gutmann was married to Miss Emma Wilkins at Chicago, June 24. Mr. Gutmann, who is a graduate of one of the German universities, is at present electrician of the Royal Electric Company, Peoria, Ill.

Mr. Wm. D. Ray, general manager of the Everett Railway & Electric Company, Everett Wash., was a recent visitor in Chicago. Mr. Ray reports business looking up in his state and believes that the prospect for electrical business is encouraging.

Mr. Cyrus Robinson has resigned his position as manager and engineer of the Jeffrey Manufacturing Company, of Columbus, O., and taken charge as general manager of the sales department of J. H. McEwen Manufacturing Cempany, 26 Cortlandt Street, New York.

Mr. Seirio Mine, electrician for the Department of Communications of the Government of Japan, is on a visit to the United States for a five mouths, professional tour, during which he will make a technical study of American methods in electrical engineering and street railway systems.

Mr. L. W. Kingsley, secretary of the Mica Insulator Company, recently sailed on the steamship, "St. Louis," for a trip abroad, where he will spend considerable time sight seeing, as well as looking after the affairs of his company in Europe, at whose newly equipped factory, located at Stoke-Newington, London, upward of 100 hands are now employed.

Mr. Michael J. Sullivan, widely known as an electrical journalist, died in Washington, D. C., on June 12, of appendicitis. Mr. Sullivan was at one time editor and proprietor of the late *Street Railway Gazette* and more recently represented the *Electrical World* as its Western manager. A man of brilliant parts and genial personality, his untimely death is deplored by hosts of friends.

Dr. Frederick Bedell, of Cornell University, was married to Miss Mary L. Crehore, daughter of the late John D. Crehore, of Cleveland, O., in St George's Church, London, England, on July 1. Dr. Bedell is one of the foremost representatives of American electrical science. His treatise on alternating currents is widely used in college courses and has been translated into German and French.

Lieut. S. Dana Greene, assistant general manager of the General Electric Company, was married in Batavia, N. Y., on June 25, to Miss Cornelia Chandler, daughter of the late Rear Admiral Chandler, of the United States Navy. Lieutenant Greene himself comes of a family distinguished in naval and military history. His father was second in command of the Monitor during its engagement with the Merrimac, and in full command during the greater part of the battle, owing to the disablement of Captain Worden, shortly after its commencement.

Lieut. Manning K. Eyre has been promoted to the general managership of the Edison lamp factory, at Harrison, N. J., the duties of which position he has been discharging for some months since the resignation of Mr. Francis R. Upton. Lieutenant Eyre has arrived at this important position through successive steps of promotion during the past three years, starting from a minor position in the lamp selling department. Besides possessing executive ability of a high order, much of his success has undoubtedly been due to sterling personal qualities which command the good wishes of all with whom he comes in contact.

NEW BOOKS.

SOMETHING ABOUT X RAYS FOR EVERYBODY. By Edward Trevert. Lynn. Bubier Publishing Company. Paper covers. 78 pages. Price, 25 cents.

This pamphlet contains a compilation of odds and ends of matter relating to Röntgen rays, and a detailed description of an induction coil. It is doubtful if the coil described is suitable for Röntgen ray work.

THE PRACTICAL MANAGEMENT OF DYNAMOS AND MOTORS. By Prof. Francis B. Crocker and Dr. Schuyler S. Wheeler. Fourth edition. New York: D. Van Nostrand Company. 206 pages, 99 illustrations. Price $1.50.

With the present edition this excellent practical manual enters into its seventh thousand. Those engaged in the operation of dynamos and motors will find this work by far the best published relating to directions for practical working, testing and localization of faults.

ELECTRIC ARC LIGHTING. (Elementary Electro-Technical Series). By Edwin J. Houston and A. E. Kennelly. New York: The W. J. Johnston Company. 383 pages, 155 illustrations. Price, $1.00

This handsome little volume has been prepared more particularly for the general public, in order to inform them of the general principles underlying arc lighting and the construction of the apparatus employed. Some of the chapters, particularly the ones on the early history of arc lighting and on light and illumination, will be found of interest and value by the professed electrician.

ELECTRIC LIGHTING. Vol. I. The Generating Plant. By Prof. Francis B. Crocker. New York: D. Van Nostrand Company. 444 pages, 152 illustrations. Price, $3.00.

This is the first volume of what promises to be the most complete and satisfactory work on electric lighting yet written. The present volume treats of the elements of an electric lighting plant and the methods of generation, the subjects of distribution, lamps, special applications, etc., being left for a succeeding volume. The location, general arrangement and buildings of electric lighting plants; steam, gas, oil and hot air engines; water wheels and windmills, are taken up in turn. Gearing, direct coupling, belting and shafting are next treated. The subjects of dynamos and their management, storage batteries, switchboards, instruments and lightning arresters are considered in the final chapters.

TRADE PUBLICATIONS.

Power Pumps. The Goulds Manufacturing Company, Seneca Falls, has issued a handsome half-yearly calendar—commencing with July—which includes for each month an illustration, beautifully executed, of a power pump, a different type for each month. The engravings are made from washed drawings, and being printed on a tinted background, produce a handsome effect.

The Royal Alternator. With the title, "Facts Worth Considering and of Interest to You," the Royal Electric Company, of Peoria, Ill., publishes a twelve-page pamphlet consisting entirely of letters received from customers. No comment is added, the facts here presented by users in their own language being sufficiently convincing of the worth of the apparatus to which the letters refer.

Electrical Bell Hangers' Guide. With this title C. M. Turnquist, 216 South Canal Street, Chicago, has issued a 40-page pamphlet giving a number of bell-hangers' diagrams and a catalogue of supplies, tools, wires, etc., used by electricians, bell-hangers, experimenters, inventors, and amateurs. The diagrams will be found useful, as they show some combinations not familiar to all electricians. The pamphlet is sold at ten cents.

The Commercial Dynamo. A neat pamphlet issued by the Commercial Electric Company, Indianapolis, Ind., contains illustrations of types and details of the "Commercial" dynamo, and in few words brings out the advantages which have led to the continued success on the market and in use of this well known machine. This was one of the earliest dynamos in this country to use an all wrought-iron field, and has demonstrated that the theoretical advantage of wrought-iron over cast-iron of five to one is also a practical advantage.

Gasoline and Gas Engines.—In a 40-page catalogue the Van Duzen Gasoline Engine Company, of Cincinnati, O., discusses and illustrates the seven different styles of engines which it manufactures, consisting of gasoline engines, gasoline and gas engines combined, stationary gasoline engines, portable gasoline engines, gasoline engines and pumps combined, gas engines and pumps combined, portable gasoline engines and pumps combined. Among the illustratsons is one showing a dynamo run by a gas and gasoline engine of 10-HP.

An Electrical City.—We are indebted to the People's Electric Supply Company for a handsome pamphlet descriptive of Madison, Wis. From it we learn that in the city, though having a population of but 18,000, there are $710,000 invested in electrical enterprises. The central station supplies no less than 16,000 incandescent lamps, 300-KW of power and 200 arc lights, while the street railway operates fifteen motor cars, besides trailers. Not the least source of pride to Madison is the course in electrical engineering at Wisconsin University which, under the charge of Prof. D. C. Jackson, has attained an enviable national reputation.

An Edition de Luxe. The new catalogue of the Stanley Electric Manufacturing Company, just issued, is an admirable specimen of the engraver's and printer's art. All of the various types of Stanley-Kelly apparatus are illustrated by half tones—made by Bartlett—which in beauty of execution far exceed any photo-engraving work that has ever come under the notice of the writer. The text explanatory of the illustrations and of alternating work in general is clear and concise, forming an interesting technical treatise on current practice in this important field. The entire artistic and mechanical execution of the catalogue was in the hands of Bartlett & Company, and the result is another triumph for their artistic staff and the Orr press.

BUSINESS NEWS.

The Largest Leather Belt in the World. The Chicago Belting Company has made for the Louisiana Electric Light Company, New Orleans, La., the largest leather belt ever constructed. The belt is three-ply, 84 ins. wide, 150 ft. long and weighs 3300 lbs.

The Metropolitan Electric Company, Chicago, has taken the Northwestern Agency of the Missouri Telephone Manufacturing Company, St. Louis, Mo., and is carrying a full line of its justly celebrated telephones, switchboard apparatus and patent gravity hook. All telephones are guaranteed.

The Triumph Electric Company, Cincinnati, O., has secured the order for two 40-KW and 20 KW direct-connected multipolar generators with panel switchboard for the Ohio State Hospital at Columbus. The machines will be run by Buffalo Forge Works engines. Alex. Schulmann, of Cincinnati, secured the contract for wiring.

E. P. Roberts & Company, Cleveland, O., are electrical and mechanical engineers for the Columbus (O.) State Hospital, whose electrical plant is to consist of two 40-KW direct connected units; also for the Massillon (O.) Insane Asylum electric plant, to consist at present of two 50-KW direct connected units; this plant will be doubled in the future.

The American Electric Company, Detroit, Mich., has installed a complete electric lighting plant in the Oakland Hotel and cottages, at St. Clair Springs, Mich. A 35-KW Crocker-Wheeler dynamo with Perkins lamps are used. The plant was installed under supervision of Wm. T. Benallack, electrical inspector for the Michigan Inspection Bureau.

The Willard Electric & Battery Company has been incorporated at Cleveland, O., with a capital stock of $20,000, and will continue the manufacture of the Willard storage battery. The incorporators are E. N. Hawley, Chas. Suhr, T. A. Willard, H. N. Hawley and W. N. Morrow. They are now in good shape to handle large orders and will make a specialty of central station battery plants.

C. M. Turnquist, 216 South Clark Street, Chicago, Ill., is placing on the market a new battery called the "Monarch Plunge Battery, King of Acid Batteries." For running small motors, lighting small incandescent lamps, operating induction coils and for experimental work where a strong electric current is required this battery is claimed to have no equal. The battery will be ready for the market Aug. 1.

The Electrical Exchange, 183 Lake Street, Chicago, has bought the entire stock of electrical supplies of Jones Brothers, Cincinnati, and removed the goods to its Chicago warerooms. Among recent sales of the Electrical Exchange are the following: One 50, one 100 and two 500-light Mather dynamos; one 500-light alternator; one 75-light and one 60-KW Edison generators; four motors, from 1 to 6 HP, and transformers for over 2000 lights.

The Northern Electrical Manufacturing Company, Madison, Wis., is having gratifying success with its steel-clad spherical motors, which recently were adapted for use in the new Library of Congress, building at Washington. Appreciating the requirements of the present day, the shops of the company have been equipped with the highest grade of machinery and facilities provided for turning out work of the highest class at a minimum cost.

Remarkable Water Wheel Governor Performance. The Replogle Governor Works, Akron, O., in a recent circular gives an account of a thorough test of the Replogle water wheel governor made by the Citizens' Railway Company, at Fishkill on-Hudson, N. Y. For a fifty-five per cent. variation in load on the railway generator, the speed varied less than two per cent., and between no load and an overload the revolutions only varied between 105 and 101.

The Palermo Mica Company, 27 Peck Slip, New York, one of the oldest firms engaged in mining and in importing mica for all the uses to which it is put, has recently resumed the manufacture of mica especially for the electrical trade. The stock which it uses for this purpose is of the very best quality and is furnished in any desired shape or size. This company received a medal and the only diploma awarded for mica at the World's Columbian Exposition of 1893.

The Van Auken Steam Specialty Company, 203 So. Canal St., Chicago, has a few more handsome celluloid 45-deg. triangles which contain a scale, to send to applicants interested in draughting and steam specialties. It is also distributing, free of charge, a book showing how to do away with wiping or soldering lead joints. This system of connections is revolutionizing the art of plumbing, and should be looked into by everyone who has to do with lead pipe fitting.

Messrs. Ford & Bacon, 203 Broadway, New York, are engaged upon the details of a plan whereby the great establishment of the American Lithograph Company, New York City, will be equipped throughout with electric power. This firm were consulting electrical engineers for the Cooper-Seigel building, which when completed will have an electrical installation consisting of more than 6000 incandescent lamps, 500 arc lamps and a complete electric power service, including elevators.

The Capo-Farad Battery & Appliance Works. The entire business and plant of the Capo-Farad Battery & Appliance Works, of 27 Thames Street, New York, has recently been purchased by Mr. Arthur J. Farnsworth, of Mamaroneck, N. Y. Mr. Farnsworth, it is understood, intends to enlarge its scope and usefulness in the electrical field in the near future by undertaking, in addition to the manufacture of the well known Capo-Farad battery, all kinds of model and repair work and construction battery apparatus.

Sunbeam Lamp. The demand for the 2 CP and 4 CP Sunbeam lamp, manufactured by the Sunbeam Incandescent Lamp Company, Chicago, is rapidly increasing. This lamp is especially appreciated by those central stations which have suffered a loss in their residence lighting owing to the competition of the Welsbach burner. With these lamps, lighting companies can give residence customers double the number of lights as heretofore, without increasing the size of their monthly bills, and thus making incandescent lighting far more convenient than any other form of illumination.

The Mica Insulator Company, 218 Water Street, New York, is sending out a card folder to which is attached a sample of flexible micanite plate "Style B." The plate is made of pure India sheet mica, and is the latest production in extra flexible mica. This grade is especially suitable for armature and field magnet insulation, its flexibility being such that it may be bent to any shape required, even in the thickest plates made. The Mica Insulator Company reports that the demand for its specialties is on the increase both here and in Europe, and that its London and Schenectady factories are kept very busy filling orders.

Bicycle Lamp. The bicycle electric lamp made by the Ohio Electric Works, Cleveland, O., is meeting with much success. We take the following from the manufacturers' circular just issued: "The battery is 5 × 2 × 2 ins., weighs ten ounces, and will maintain a potential of not less than 3.5 volts for more than four hours on each charge, costing two cents. The lamp is of double the efficiency of ordinary incandescent lamps, taking only 1½ watts to the candle power, and is backed by a scientifically correct and powerful reflector. By electricians it has been regarded as paradoxical, but all scepticism is removed on examination of the efficiency of the lamp, battery and reflector. Economy is wealth, and by its proper exercise we are enabled to produce an efficient electric light for carriage or bicycle at a popular price."

American Electrician.

Vol. VIII. New York, August, 1896. No. 4.

ELECTRICITY IN THE UNITED STATES NAVY.

By Frank W. Roller.

In laying out the scheme of lighting for a new vessel in the United States Navy very much the same plan is followed as is the case with modern isolated plant work.

First, a complete set of plans and specifications is drawn up, the former being sketched in on blue prints of the various decks and the latter being printed for distribution. Everything from and including the generators and engines and ending with the lamps themselves, is included, a considerable latitude, however, being allowed to the officer designated as inspector in charge of the work.

Starting in with the generating sets, here as all through, the requirements are much more rigid than is the case ashore. The engines must not only be as light and compact as modern engineers are able to build them, but they must in addition be able to govern closely and run on almost anything from steam to hot water. Of course, this latter requirement, necessitating as it does large cylinder clearances, reduces the efficiency somewhat, but as priming of the boilers is a common evil, immunity from accidents due to water in the cylinder is absolutely essential.

The simple automatic, vertical, double-cylinder, double-acting engine has been found to best meet the requirements and is now invariably used. As built at present, they are capable of being taken entirely apart in a space but a few inches higher than that they occupy and to run continuously without any lubricants whatever in the steam spaces.

Contrary to the usual practice in foreign navies, the generators are all multipolar and, of course, compound wound. Their voltage (80) perhaps strikes one at first as being an odd one to chose, but when it is remembered that the lengths of runs are short and that the search lights, consuming from 50 to 150 amperes each, need only 50 volts across their terminals, the object in using it is more apparent.

The specifications that the generator must fulfill are exceedingly rigid, sparkless running and low heating limits being strongly

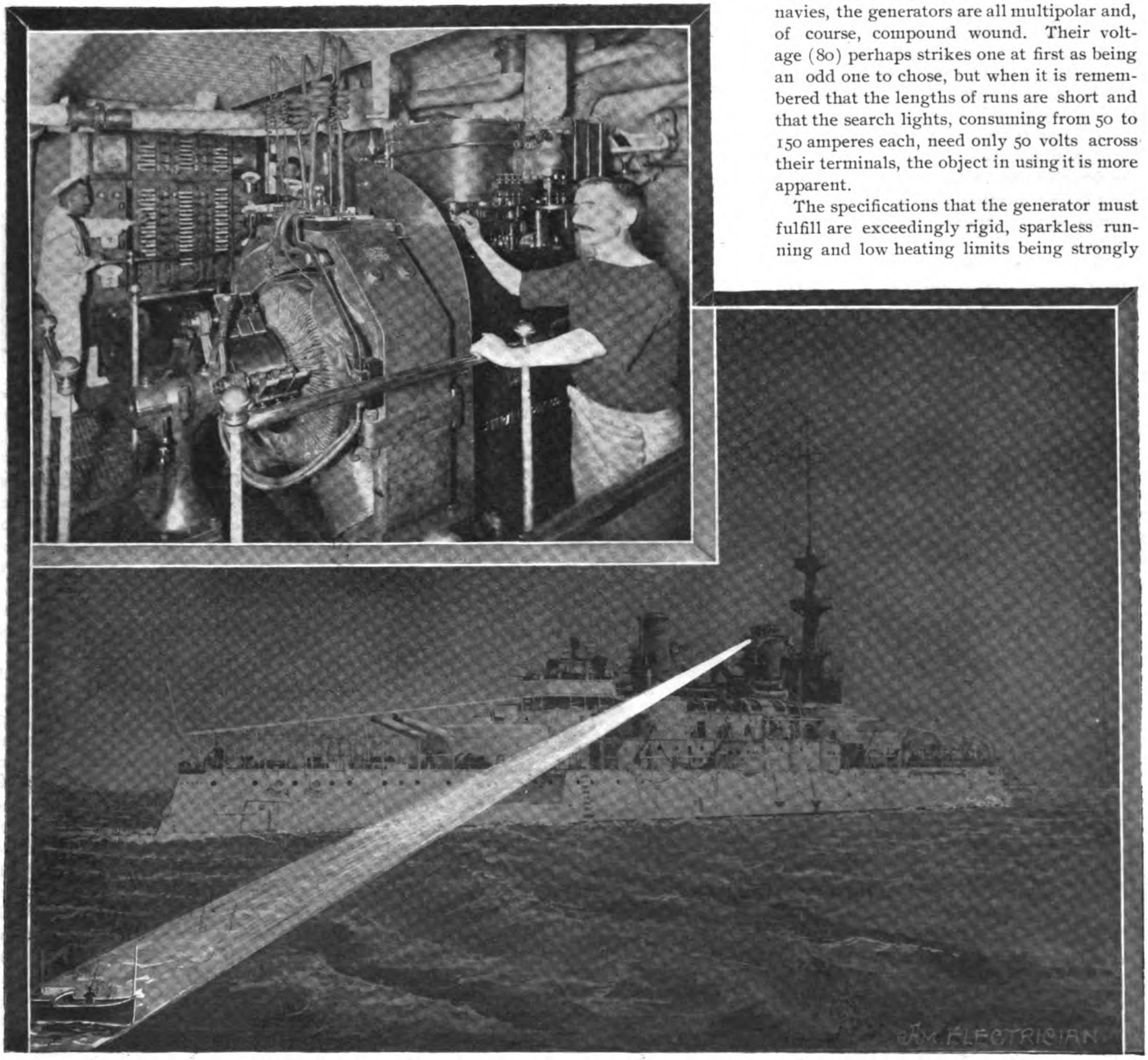


FIG. 1.—U. S. S. BATTLESHIP "OREGON."

insisted upon. The maximum rise in temperature of any part of the machine must not exceed 50 degs. F. above the surrounding temperature, while at the same time the efficiency must be such that at least four watts are generated at rated capacity for every pound weight of the generator, including its sub-base. The presence of any stray field must also be avoided, any magnetism that can be detected over twenty-five feet in any direction with a sensitive horizontal force instrument being sufficient to cause the rejection of the outfit.

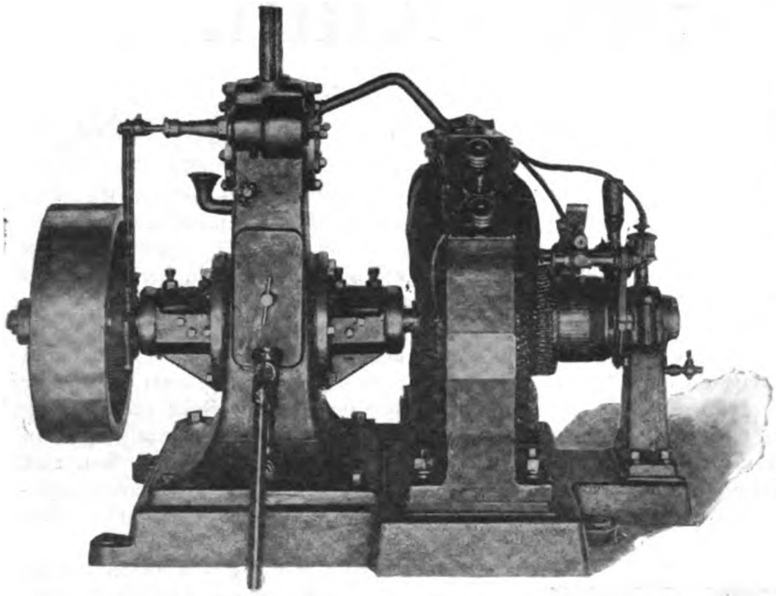


FIG. 2.—LATEST TYPE OF GENERATING SET.

To such an extent have these machines been perfected that they have frequently carried overloads of 100 to 150 per cent. of rated capacity for extended periods without any sparking or undue heating. Views of the latest type of generating set are shown in Figs. 2 and 3. A type installed on a number of vessels is also shown in Fig. 4.

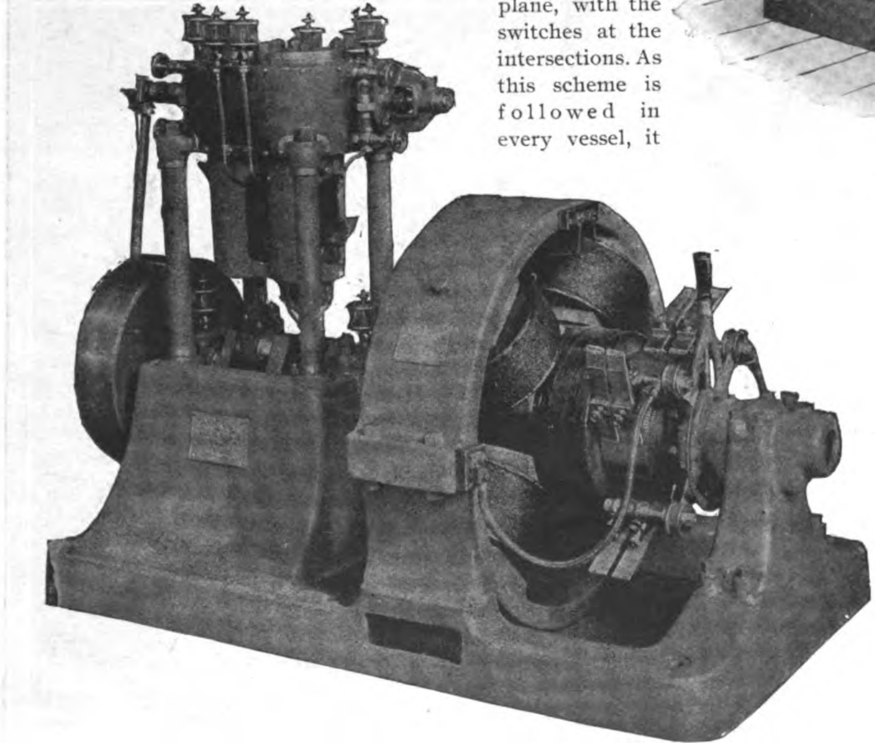


FIG. 4.—TYPE OF GENERATING SET.

Each vessel carries a plurality of duplicate units, and the switchboard controlling them is so arranged that the dynamos may be run either singly or in multiple on the incandescent circuits, either singly or in multiple on the search light circuits, and either singly or in multiple on the search light and incandescent circuits connected in multiple.

To this end a switchboard has been designed, of which a view and a diagram of connections are shown in Figs. 5 and 6, the board being that installed on the U. S. S. "New York." It will be noticed that the arrangement is a very simple one, all dynamo circuits being in a vertical, and all branch circuits in a horizontal, plane, with the switches at the intersections. As this scheme is followed in every vessel, it is possible for a person familiar with any one board to operate any other at sight, this point being of great advantage where men are so frequently transferred from one ship to another.

Nowhere than in the wiring aboard ship can be found a better illustration of the care with which an electric installation is put in on a man-of-war. Only the highest of high grade materials rigidly inspected are allowed, and the work is done by a trained corps under the immediate supervision of experts in this line. Two entirely independent sets of circuits are always run. One is designated the "battle circuit" and includes all lights necessary in a day or night action. The other, or "lighting circuit," takes in all lights not so needed, and is controlled at the switchboard, this method having the advantage that in going into action it is unnecessary to hunt around to see if any unauthorized lights are on, they being all turned off from the dynamo room at such times.

The "battle circuit" is, if possible, installed with even greater care than the lighting circuit, all ends of the mains being interlocked and cross-tied at many places through the ship, and all being kept as much as possible below the shield-shaped protective deck covering the ship's vitals. The feeder and main system is employed, the former being so liberally distributed that the greater portion of the latter may be shot away or otherwise rendered inoperative without materially interfering with the lights. Double-pole switches in water-tight cases, as shown in Fig. 7, are employed at all junctions, so that the different sections may be isolated for tests.

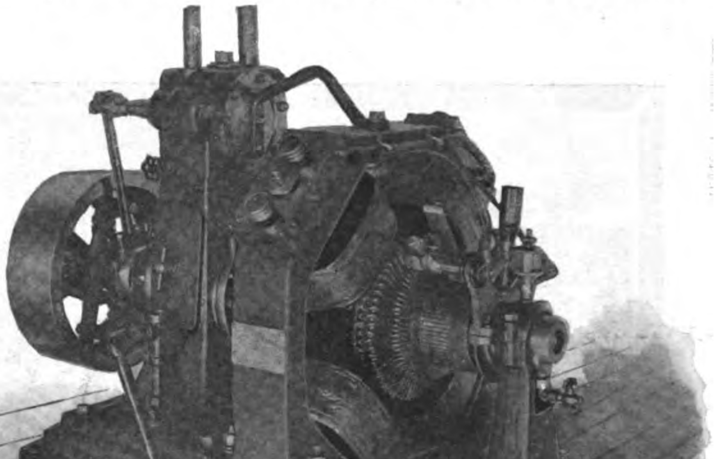


FIG. 3.—LATEST TYPE OF GENERATING SET.

When the first modern ships were wired, lead-covered cables run in moulding were employed throughout, the lead jacket being supposed to protect the insulation from water and to a certain extent from mechanical injury. Considerable trouble was experienced, however, by the denting and breaking of the armor when the wires were put in, the moisture which then entered causing bad grounds and frequent short circuits. The weight and cost of the wires were also serious objections to its use. All the wire now is without any armor whatever, the extra heavy insulation being sufficient to obviate trouble from water, and the moulding in which it is encased affording the necessary mechanical protection. As the circuits in the fire and engine rooms are especially liable to trouble, the experiment was tried a few months since of running the circuits therein in ordinary iron-armored insulating conduit. These have not yet been installed long enough to demonstrate their value, but there is every reason to suppose that they will be successful, as there is certainly no possibility of a fireman playfully jabbing his slice bar between two live wires "just to see what will happen," as has been known to be the case in one instance at least where moulding was used. The following description of the material used, taken from the specifications for wire for the lighting circuits of one of the new cruisers, may be of interest :

sent by the contractors to the New York Navy Yard for test. The test is as follows, failure to meet which will involve rejection :

Both samples after twenty-four hours' immersion in sea water, must have an insulation resistance of not less than 1000 megohms per nautical mile, the test being made at 72 degs. F., and the time of electrification being one minute. The physical and electrical characteristics of the insulation should not change when the conductor, complete, is raised to the temperature of boiling water, nor upon cooling. Chemical tests are made to determine the constituents of the different layers of the insulation.

The right is reserved to test any of the wire at any time before the final completion of the plant, and to reject any wire that is not in every respect equal to the accepted samples.

Portable wire is required to be double conductor, each strand composed of twenty untinned copper wires No. 30 B. W. G. The insulation of each conductor consists of a fine braid saturated with a cement containing no sulphur, brown rubber and braid.

For silk-covered portable wire, each of the two conductors, insulated as above, is covered with a braid of heavy machine-twist silk, and then the two conductors stranded together; the external diameter of the finished cable not exceeding ¼ in.

For deck portable wire, two conductors, insulated as above, are stranded together, using a jute filling and then the whole is covered with a layer of brown rubber, braid, and finally, a heavy braiding of flax, soaked in a waterproof mixture. The external diameter of the finished cable is not permitted to exceed ⅜ in.

The moulding in which these wires are run is of much the same pattern as that used ashore. It is of pine, capped and double painted and is secured to the ship's side or wherever it may run at intervals of no more than twelve inches. Where wires pass through the various bulkheads and beams the holes are bushed with ordinary hard rubber tubing. In some cases, however, as in going through a water-tight bulkhead, special stuffing boxes are employed, made of brass lined with hard rubber tubing and having soft rubber glands at the ends. These are illustrated in Fig. 8, the one with the thin plates being used under ordinary circumstances and the other where it is necessary to go through protective or other curved decks.

All switches, fixtures, junction boxes, etc., are secured to wooden bases in order to di-

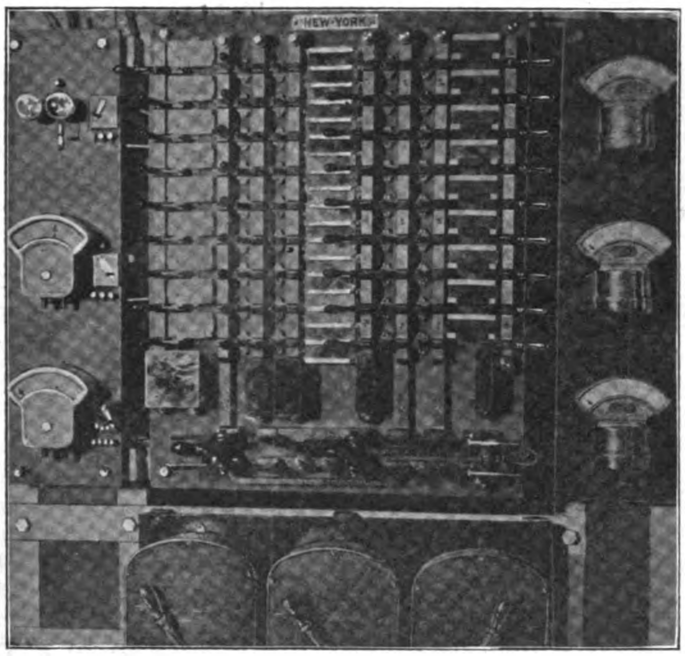


FIG. 5.—SWITCHBOARD OF U. S. S. "NEW YORK."

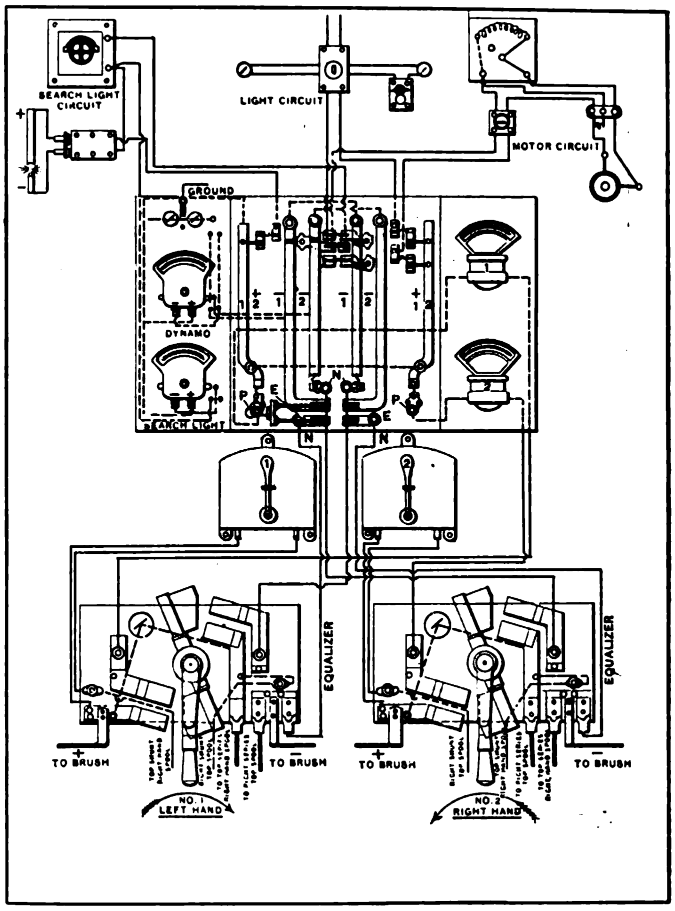


FIG. 6.—DIAGRAM OF SWITCHBOARD OF U. S. S. "NEW YORK."

The conductors are of soft annealed pure copper wire, no single wire being larger than No. 14 B. W. G.; conductors are stranded when greater conducting area is required, and no single finished conductor smaller than No. 16 B. W. G. is used. Each wire is heavily and evenly tinned. All conductors, except certain fixture and portable wires, are insulated as follows : First, a layer of pure para rubber; second, a layer of rubber containing no sulphur; third, a layer of vulcanized rubber; and fourth, three heavy braidings of cotton, each thoroughly saturated with a waterproof compound. The thickness of the insulation, excluding the braid, is not less than 3/32 in. and not greater than 4/32 in.

Two samples each 500 ft. long, are selected from the coils of wire to be supplied, and

FIG. 7.—WATER-TIGHT SWITCHES.

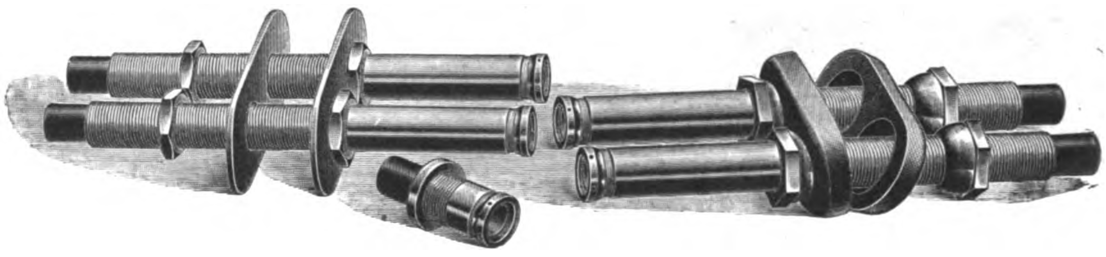


FIG. 8.—WATER-TIGHT BULKHEAD BUSHINGS.

minish chances of a ground. As each circuit must test out at least one megohm, and as all circuits in parallel must show an insulation resistance of at least 500,000 ohms from each other and from the ground, this is only one of the numerous precautions that must be taken. Even then the insulation demanded can only be obtained in warm, dry weather, the principal object in specifying it being to secure all possible care in installation. Even the circuits connecting the telephones, engine room telegraphs, fire and water alarms, call systems, etc., etc., must show the same insulation as the above, as any cross from the lighting circuit might prove disastrous. It may be remarked here that the current for operating the devices just mentioned is obtained at all times when the dynamos are in operation from an ordinary motor-generator and at other times from Leclanché cells. Fig. 9 is a view of the electrical testing room at the New York navy yard.

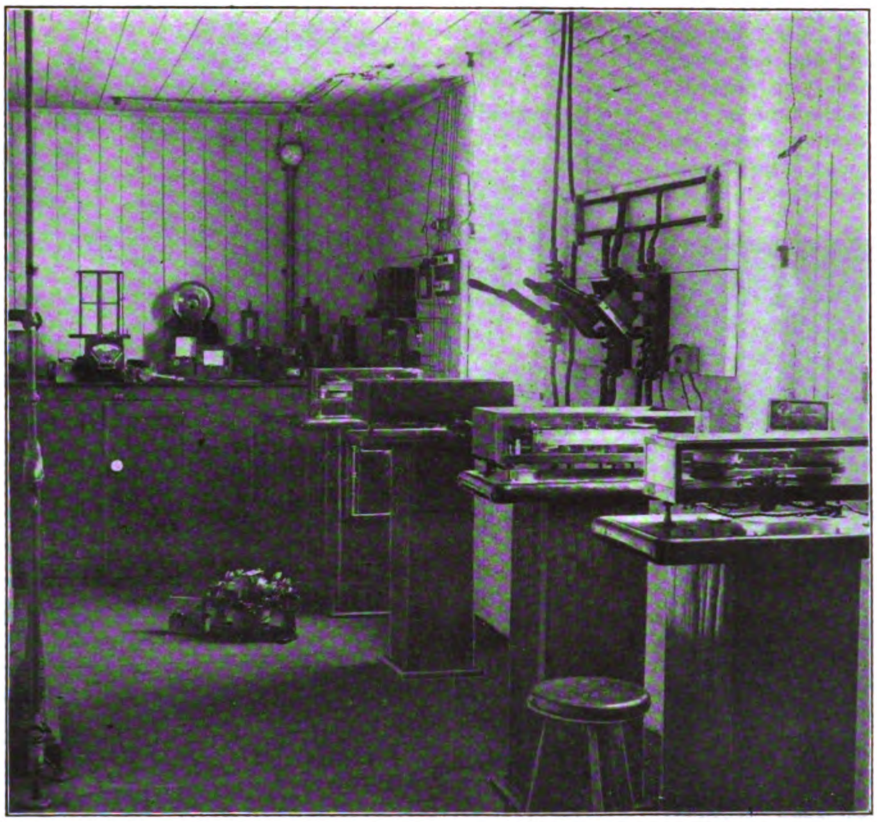
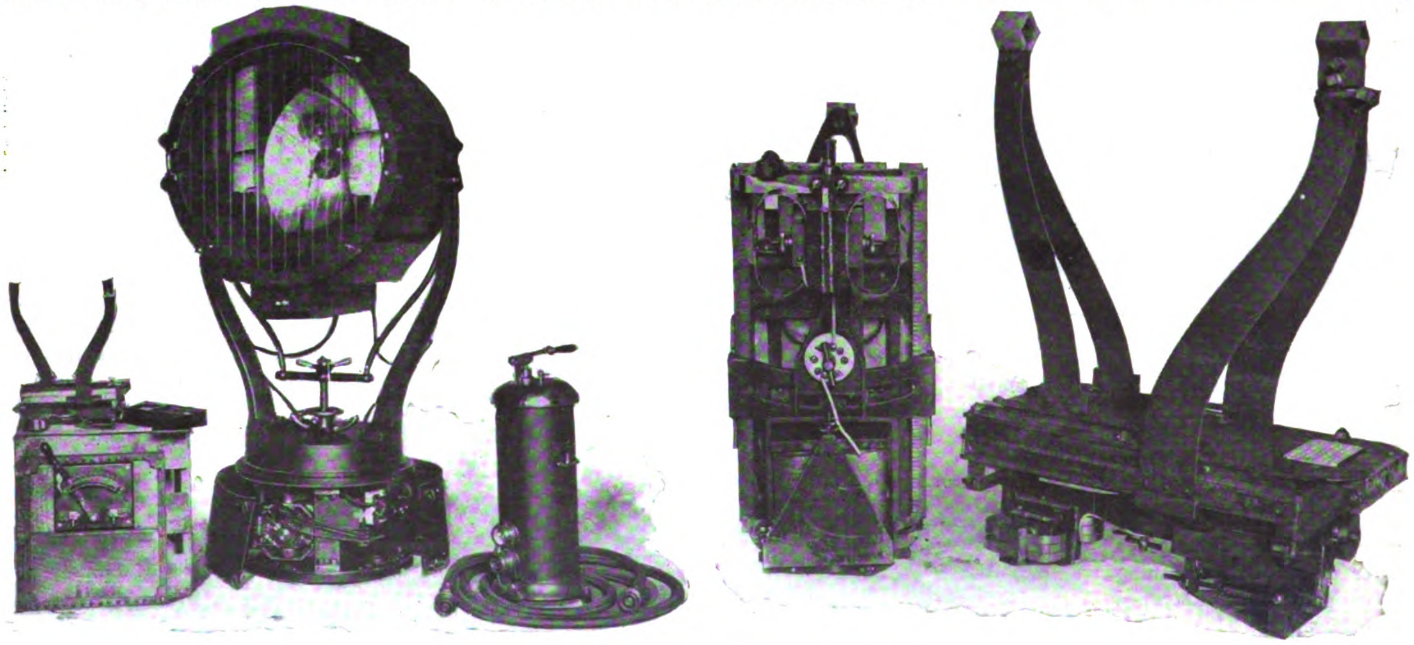


FIG. 9.—ELECTRICAL TESTING ROOM AT NEW YORK NAVY YARD.

Electric motors, while at first comparatively little used in the Navy, are coming more into vogue every day. This is particularly the case in connection with the fans for the complicated ventilating systems used. Steam engines for this use, owing to the loss in power by the condensation in the piping when placed at any distance from the boilers, and to their weight, are falling into disfavor. The great amount of heat given off into the living spaces often renders their use impracticable, while the extra attention needed due to their greater complication renders them still more objectionable. In some foreign navies, where the plan of making the majority of the water-tight bulkheads without doors in order to do away with any possibility of having communication left open between them in case of accident is followed, electric motors are the only means used to drive the fans. Added to those mentioned above this has the further advantage that in case the wires leading to the motors are shot away, no particular harm results other than the stoppage of the fans, but if a steam pipe is cut, the escaping steam might disable every man in the compartment, besides being very much harder to repair. Another thing is that with the old system where a few large steam-driven fans were grouped together to give air to the whole ship, large holes had to be cut through the different water-tight bulkheads to admit the air ducts, thus not only weakening the ship, but increasing greatly the chance of water getting from a flooded compartment into its neighbor in spite of the automatic valves put in to prevent it.



FIGS. 10 AND 11.—NAVY SEARCH LIGHT.

In Fig. 12 is shown a typical navy ventilating set of small size, such as is used to furnish air to those inspecting the space between the double bottoms and other confined quarters. The larger sets, having motors ranging from $\frac{1}{2}$ to 3 HP, are much the same, except that they are usually arranged so that they may be bolted to the deck beams overhead so as to be out of the way. They are all shunt wound, controlled by automatic starting boxes, and must meet the same requirements as to heating limits, sparkless running, insulation resistance, etc., as the generators. Electricity is also used for running the amunition hoists, and motors controlled by reversing rheostats have just been installed on the "Terror" in place of the steam steering engines.

The matter of using motors to train the guns and operate the turrets is one upon which much time and thought have been expended. Certain foreign vessels employ them, but their value has not yet been sufficiently demonstrated here to warrant discarding the old hydraulic system of control. The great difficulty that has to be met is the requirement that the turrets must be absolutely under the control of the gun captains with no perceptible effort on their part. With hydraulic training, owing to the incompressible nature of water, the moving part is bound to come to an absolute stop when the valves are shut and to remain fixed until a passage is again opened. Moreover, by adjusting the size of the openings in the piping it is possible to set a limit to the speed at which the turret will revolve, it being impossible for the weight of the latter to drive the water motor used at a speed greater than the normal. The disadvantage of hydraulic power that the pipes are liable to burst and the valves to leak is, however, a serious one, and if electricity can be made to do the same work without requiring increased space or being more difficult to manipulate, it will undoubtedly be adopted.

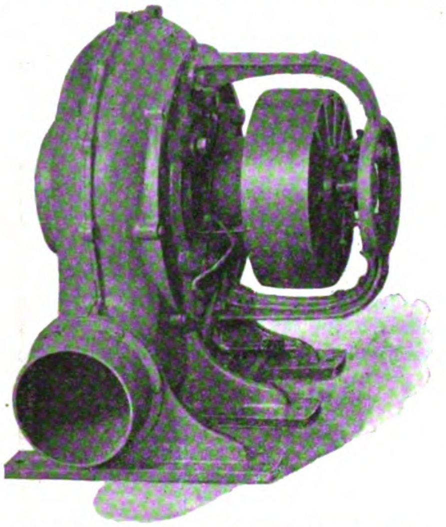


FIG. 12.—ELECTRIC VENTILATING SET.

An almost instantaneous stop, ability to move through arcs of a few minutes or seconds only, a speed variable at the will of the gun captain and a sufficient torque under all circumstances to move the turret and so prevent stalling of the motor with its consequent blowing of fuses, are a few more of the requirements it is necessary to meet.

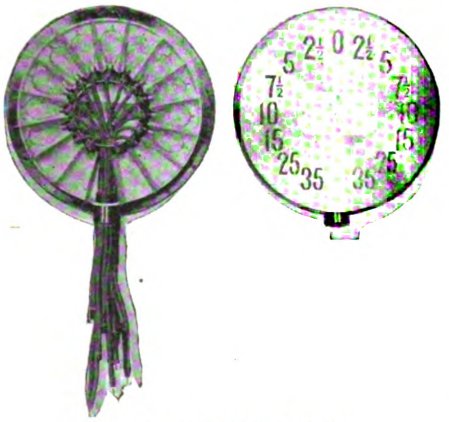


FIG. 13.—HELM INDICATOR.

One of the largest electric manufacturing concerns in the country thinks it has solved the problem, and is now installing its apparatus on a new man-of-war where it will be practically tested in competition with the hydraulic system, also being put in place. The result of this effort is being awaited with much interest by professional men, and should all go well the impetus given to the use of electric power aboard ship wherever available will be considerable.

Of late many of our men-of-war have been equipped with search lights operated by motors controlled from a distance. This method having, as it does, the advantage of allowing commanding though exposed positions to be utilized for the light while the operator is shielded, both from the glare and from hostile fire, seems a decided advance. The additional weight and the greater complication are, however, great drawbacks, so that their actual value is still in doubt.

The latest controllers, one of which is shown standing beside its search light in Fig. 10, have, as may be seen, only one handle.

The connections are such that a vertical motion of this handle will cause the barrel of the lamp to move vertically and a horizontal one, horizontally, a combination of the two being also possible to get a motion of the beam at any desired angle with the horizon. Some successful night signaling has been done in this way, and the advantage of having it to fall back on in case of disablement of the regular signal apparatus would be great, as a beam of light thrown on a cloud is visible at a great distance.

It would be impossible in this article to even touch upon the numerous other ways in which electricity is brought into play to facilitate the control of a war vessel. One of the devices, however, that shown in Fig. 13, we may mention here as illustrating the simplicity of construction and the certainty of operation constantly aimed at. It is a "helm-indicator" and shows approximately what angle the rudder is making with the keel at any instant by the lighting of the lamps behind the perforated cover marked 0-2½-5, etc. (degrees). When the helm is put over, current is sent through the lamps in turn by a contact arm fastened to the rudder post which sweeps over a series of contacts spaced 2½-5, etc., degs. on each side of the center line, each one, of course, completing the circuit through its corresponding lamp.

This device, it would seem, could be readily adopted in modern office buildings to indicate the floors that the different elevators are passing.

◆

Loss from Uncovered Steam Pipes.

In a recent report made to the Canadian Pacific R.R. Company, by one of its engineers, of some tests of various kinds of steam lagging, the following table was included, showing the loss of power that has been found to take place from uncovered pipes filled with steam at seventy-five pounds gauge pressure:

2	in. pipe.	1-HP	loss for	every	132 ft.	of length.
4	"	1 "	"	"	75	"
6	"	1 "	"	"	46	"
8	"	1 "	"	"	40	"
12	"	1 "	"	"	26	"

About ninety per cent. of this waste, it was added, can easily be prevented by a proper covering of the pipes. When it is considered that this loss occurs at the comparatively low pressure of seventy-five pounds, it is apparent that with steam at 130 lbs. and 140 lbs. and higher, the loss becomes very serious.

TRANSFORMER "LEAKAGE CURRENT."

By Prof. Dugald C. Jackson.

A time-worn tradition will often make a striking obstruction in the path of progress, but fortunately for the electrical industries their traditions have not reached hoary distinction and they commonly are easily destroyed. A few have become quite deep seated in comparison with their life; and amongst these is the general belief of central station men that the magnitude of the so-called "leakage current," or truly, the exciting current, of transformers is a measure of transformer losses.

The belief is a natural one which was transmitted directly from electrical manufacturers, the best of whom up to five years ago ranked their transformers according to the "leakage current," and taught their customers to do the same. But all foundation for accepting the "leakage current" as an indication of the worth of a transformer was exploded when a knowledge of the effects of hysteresis became general, and the manufacturers who understand their business have for the past five or six years built their transformer cores out of carefully tested iron, which is selected on account of the small hysteresis effect. It is this hysteresis effect which causes ninety per cent., or thereabout, of the core loss which wastes power in transformers; so that the actual waste of power in the core, instead of the "leakage current" which is in part a wattless magnetising current, should be the criterion of losses in transformers. In fact, the actual loss of power in the cores of transformers having exactly the same "leakage current" may differ as much as five to eight.

This is plainly shown by the accompanying table of the core losses and exciting currents (leakage currents) of some 1500-watt transformers tested on 1000 volts pressure at a frequency of 125.

Core Losses and Exciting Current.

	Core Loss. A.	Exciting Current. B.	Ratio. A/B.
1	26.5	.043	620
2	32.2	.052	620
3	35.	.055	636
4	43.2	.077	560
5	45.7	.054	850
6	50.5	.076	666
7	57.5	.073	790
8	95.	.200	475
9	120.	.300	400
10	126.	.173	720

The ratio column in the table shows plainly that there is no fixed relation between the amount of power wasted in the transformer core and the exciting current ("leakage current"); and the relative magnitude of the quantities in columns A and B are still more instructive to the central station man who thinks "leakage current" is the proper criterion to be used for the comparison of transformers. It chances that the transformers with the lowest leakage currents of the table are from the same manufacturer and have the least core losses, but there is a difference between leakage currents of Nos. 4 and 5 of the table of over forty per cent. in favor of No. 5, though No. 4 has a slightly less core loss; and there is practically no choice between the exciting currents of Nos. 4, 6 and

7, though there is over thirty per cent. difference in their core losses. Again, there is practically no difference in the exciting currents of Nos. 2, 3 and 5, though there is a difference of over forty per cent. in their core losses.

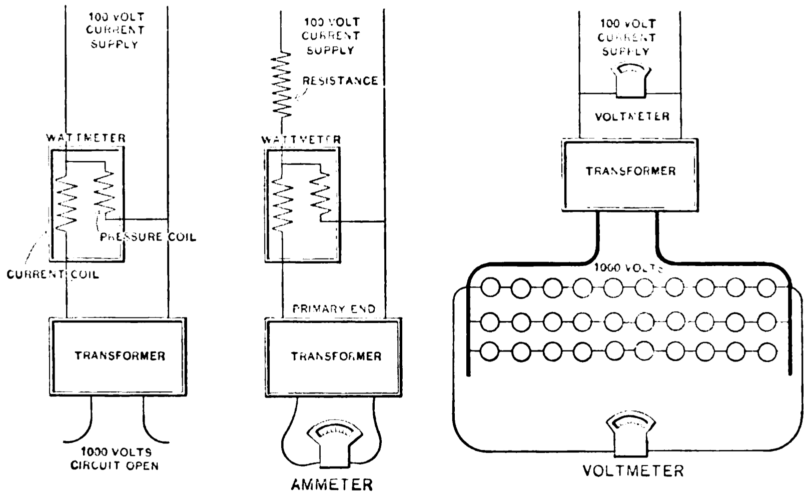
Now let us see what effect on the station the choice of transformers by the different criteria makes, and for this purpose we will make a comparison between Nos. 1 and 6, as the losses and exciting current have nearly the same ratio in the two. Assuming, as a matter of comparison, that a station is operating 100 transformers of the capacity considered, then the first station must supply 4.3 amperes to supply the exciting current and put out 53.6 KW-hours per day of twenty-four hours to supply the core losses. The second station must furnish 7.6 amperes to supply the exciting current, an increase of about two per cent. of the total current capacity of the transformers, and must put out 121.2 KW-hours per day of twenty-four hours to supply the core losses. The difference in the exciting current here is a matter of comparatively small moment in its effect on the capacity of the generator, but the difference in the core losses of 67.6 KW-hours per twenty-four hours means 24,674 KW-hours in a year of 365 days. If this power costs the station five cents per KW-hour, there is a dead loss of $1233 per year on account of the greater core loss, while, as I have already said, the difference in the exciting currents is a matter of comparative indifference to the station.

This is all so evident that it would not seem worth while to occupy space in a technical paper with a statement of the facts, were it not that some makers of transformers still advise their customers to test their transformers by "leakage." The result of such advice is shown in a letter lately received by me from the capable manager of a well conducted central station in which the following sentences occur: "In making tests for leakage I use the———method which gives the result in per cent. loss. I cannot see the difference between leakage and iron loss and also cannot see how an ammeter can be used in the leakage test and not in the iron loss test." The name which is left blank in this quotation is that of the maker of an excellent transformer, who is thus under the conviction of misleading his customers in regard to the correct methods of judging between transformers. (It happens to be to his own disadvantage, too.)

It is hardly necessary to add to what has already been said, that the reason for using a wattmeter and not an ammeter for measuring the core loss of a transformer is simply because an ammeter takes no account of the lag of current in the alternating current circuit, which a wattmeter does. The important points by which to judge transformers are: Core and copper losses, regulation, rise of temperature when operated under full load, and insulation between primary and secondary windings. The most important of these points—the losses and regulation—may be readily measured by any station superintendent by means of methods which are well known and which I have already presented in a simple form. The exciting current, erroneously called "leakage," of transformers which are shown to be well designed by the loss and regulation tests, carries little importance to the superintendent. In this respect, transformers differ radically from induction motors, in which the exciting current may have a greater influence on station working than the motor losses.

Following are the directions for transformer testing referred to above, which formed part of a paper read last year by Prof. Jackson before the Northwestern Electrical Association. A full account of transformer tests thus made is contained in Bulletin No. 11 of the University of Wisconsin.

To test the iron losses, the secondary coil of a transformer should be connected to a regular lighting circuit, with an ordinary wattmeter included, and the circuit of the primary coil left open; the arrangement is plainly shown in Fig. 1. The reading of the wattmeter shows the number of watts wasted by the iron loss.



FIGS. 1, 2 AND 3.—METHOD OF TESTING TRANSFORMERS.

A wattmeter such as is required for these measurements costs from $40 to $70, and is an instrument that, like the steam engine indicator, it pays to have on hand. If, however, the regular wattmeter is too expensive, an ordinary Thomson recording wattmeter, if a sufficiently sensitive and reliable one is at hand, may be used in place of it, the record taken being reduced to the basis of one hour. It is needless to say that all instruments used in such tests as here proposed must be fairly reliable.

To test the copper losses in a transformer, the quickest and easiest method and one which is approximately accurate, is to connect the primary coil of the transformer in series to the alternating incandescent circuit with some resistance (iron wire or lamps), and short-circuit the secondary coil of the transformer through an ammeter (Fig. 2). The resistance should be adjusted until the full load current of the transformer flows through the ammeter. The reading of a wattmeter so connected in circuit with the primary coil gives the copper loss, approximately.

The drop in pressure may be measured by connecting the transformer to the lighting circuits and reading the primary and secondary pressure by voltmeters. The transformer may then be loaded by lamps (Fig. 3), and the pressures again read, when the drop is at once obtained. One voltmeter may be used for this, but two are more convenient.

For the testing of individual transformers as they are delivered and before they are put on the lines, all the instruments which are required are already in the possession of the electric stations, with the exception of a wattmeter, and this is not a serious deficiency, since, if necessary, a Thomson recording wattmeter may be used instead. The testing need take but little time, and is likely to result, in average stations, in the saving of considerable waste.

Proper transformer tests enable a station manager to determine at once the amount o saving that he may make by replacing certain small transformers by one large transformer. If tests are not made, such changes may not bring the results expected, since a number of first-rate small transformers may be replaced to no advantage by a large transformer if the latter is not a good one; but usually a large transformer, if one of the best, is more desirable than several small ones, even though the latter be good.

The data in the following table will serve as guidance in selecting transformers. The second column is from data compiled by Prof. Ryan, and gives the largest current which should flow in the 1000-volt primary of good transformers when the secondary circuit is open. For intermediate capacities, intermediate values of open circuit current may be interpolated. The third column gives the values of the iron loss which should not be exceeded in thoroughly good transformers:

TRANSFORMER DATA.

Watts Capacity.	Open Circuit Currents.	Iron Loss.
1,000	.055	30
1,500		40
2,000	.080	50
2,500		60
4,000		80
6,500	.100	100
17,500	.200	150

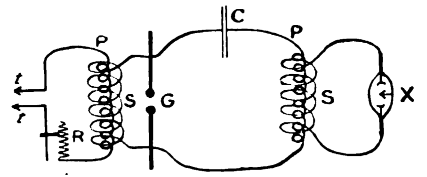
The copper losses in all sizes of transformers should never exceed 3½ per cent. at full load, and ought to be between 1 and 1½ per cent. The total drop in secondary pressure due to loading a transformer, if the primary pressure is kept constant, ought not to exceed 3½ per cent.

ON RÖNTGEN RAY APPARATUS OPERATED FROM ALTERNATING CURRENT CIRCUITS.

By EDWIN J. HOUSTON, PH.D., AND A. E. KENNELLY, SC.D.

Röntgen ray tubes may be excited from any electric source of sufficiently high E. M. F., but the simplest apparatus, probably, consists of an induction coil excited directly by a battery of storage cells through a suitable interrupter. Excellent results are, however, obtainable from an alternating-current incandescent-lighting circuit as a source of energy, the recharging of storage cells being in this way obviated.

The connections suitable for the use of an alternating-current incandescent electric-lighting circuit are represented in the accompanying figure. *t*, *t* are the terminals connected to the alternating-current mains of fifty volts pressure; *R* is a rheostat for regulating the current strength in the alternating-current circuit; *P* is the primary winding, and *S* the secondary winding of a Ruhmkorff induction coil capable of giving an eight-inch spark. No interrupter is used. The secondary terminals are led to a spark gap, *G*, between brass balls. In the absence of any other connection, a current of about ten amperes in the primary circuit will produce a continuous series of discharges between the balls over a maximum sparking distance of one inch. If the spark be examined by waving a glass rod repeatedly to and fro in front of it, it will be found to consist of a series of discharges, each corresponding to one alternation in the primary alternating current from the incandescent lighting mains. The arc between the poles is quiet, flaring and of appreciable cross sectional area.



CONNECTIONS OF APPARATUS.

If the secondary terminals are connected with a condenser, *C*, formed of, say, three Leyden jars and the primary winding, *P*, of a Tesla induction coil, the spark at *G* becomes crackling, noisy, of dazzling whiteness and continuous in character. The stroboscopic examination of this spark with the waving glass rod shows that the discharges are more sharply defined and sudden in their character, apparently one to each alternation in the primary circuit.

If a blast of air from a foot-bellows be directed through a glass nozzle between the brass balls of the spark gap, *G*, the sound of the arc becomes more rattling and its appearance rhythmically waving. The spark gap has now to be reduced to about eight millimetres or about ⅓ in. A stroboscopic examination of the spark with the glass rod shows that following each discharge at the alternating-current wave in the primary circuit there is a rapid succession of equidistant discharges which may be twelve or more in number, and which may, perhaps, almost entirely bridge over the interval between successive main alternating-current discharges. Thus, if the frequency of the alternating current from the mains be 15,000 alternations per minute, or 250 alternations per second, there will be 250 main discharges per second through the spark gap, and each such discharge may be followed by, say, twelve other discharges each separated by, perhaps, one-twentieth of the interval between main discharges, representing a frequency of 5000 alternations per second and 3000 sparks per second across the air gap. The frequency of these oscillatary discharges may be varied perceptibly by varying the number of Leyden jars in the circuit, and may be measured by attaching the glass rod to the shaft of a uniformly revolving motor and observing the angular distance between successive images.

The Tesla coil may be conveniently made by winding a coil of eighty turns of No. 18 A. W. G. cotton-covered wire in a single close layer upon the surface of a glass tube about one inch in diameter. The secondary is composed of about 320 turns of No. 30 A. W. G. silk-covered wire, also wound closely in a single layer upon the surface of a micanite tube three inches in diameter. The secondary terminals are led directly to the Röntgen ray tube, *X*.

The electrodes of this tube during the action of the apparatus are alternately the anode and cathode, while the anticathode is a platinum foil plate, bent into the form of a V. One discharge occurs in this tube at each spark across the spark gap, *G*.

The primary winding, *P*, of the Tesla induction coil is supported co-axially with the secondary winding, *S*, and both are immersed in insulating oil. This may be heavy paraffine oil, rosin oil, or kerosene oil, care being taken in the latter case that the oil is not readily inflammable. The sparking distance in air between the terminals of *S* is about five inches, and care has to be taken to prevent the apparatus from discharging through the insulating oil.

If the air blast be withdrawn, the fluorescence of the vacuum tube is fitful and the illumination produced in the fluoroscope is variable. When, however, the air blast is steadily directed across the air gap, the fluorescence of the tube is vivid and the illumination in the fluoroscope brilliant and sustained. A good radiograph of the bones in the hand can be secured in about thirty seconds, and a radiograph through the body of a boy in about six minutes, as has been demonstrated in some experiments made in conjunction with Dr. William Pepper, of Philadelphia.

The Ruhmkorff induction coil used for this purpose need be no larger than is necessary to maintain a spark discharge of 4 mm. in air under the action of the blast. We have not been able to ascertain how small an induction coil is sufficient for this purpose, but we have reason to believe that it is considerably smaller than that which is necessary to furnish an eight-inch spark in air when excited from a voltaic battery through an interrupter.

The introduction of the Tesla coil appears to be necessary in order to obtain the requisite frequency of discharge. Without the condenser, *C*, the frequency would be limited to that of the alternating-current circuit. The Tesla coil is excited with the frequency which depends only upon the reactance of the primary coil, *P*, and of the condenser, *C*. The spark discharges across the air gap, *G*, only serves to set the secondary system into oscillation, while the secondary coil, *S*, with the vacuum tube forms a tertiary system retaining the frequency of the secondary system. The capacity of the condenser has to be chosen by trial, such that the best fluorescence is obtained in the tube.

The only reason for making the diameter of the secondary winding, *S*, so large relatively to the diameter of the interior primary winding *P*, is to assist in preventing discharges through the interior of the coil. A thick glass tube placed between the primary and secondary winding will assist in maintaining the insulation of the tertiary system. All the apparatus should be carefully insulated.

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EFFICIENCY OF THE STEAM ENGINE.

The "gross inefficiency" of the steam engine is a subject of much lamentation on the part of popular writers on technical subjects. Reading that the efficiency of the steam engine is usually below ten per cent. and sometimes even less than five per cent., they rush without any inquiry as to the true significance of the term "efficiency" as used in this connection, to unwarranted conclusions, and are apt to create in the minds of readers the impression that the heat waste of ninety or ninety-five per cent. is due to the actual inefficiency of our present methods of utilizing the heat energy of coal by means of the steam engine. This, however, is grossly untrue, as will be seen from what follows.

If a weight suspended above the surface of the earth is allowed to descend to the ground, a certain amount of energy will thereby be rendered available, which may be utilized in doing useful work. If, however, when it reaches the ground the earth were to open and the weight thus permitted to continue its descent until the center of the earth were reached, it is obvious that an enormous additional amount of energy would be utilizable. It would, nevertheless, be most manifestly absurd for this reason to say that we utilize only an infinitesimal amount of the energy of a falling weight, and that the efficiency of a machine run by falling weights is infinitesimally small.

Yet when the efficiency of a steam engine is based upon the utilization of all the heat contained in the steam, the implication is scarcely less absurd. In the first case the absurdity consists in the assumption of an impossible condition—the descent of a weight to the center of the earth; in the second case a no less impossible assumption is made, for it implies the attainment of a lower temperature than exists in the universe, since at the absolute zero of temperature* that would have to be realized in order to utilize all the heat contained in steam, it is believed that the material universe itself would crumble into dust.

It may be asked, Can we imagine how a perfect efficiency might theoretically be obtained with the present form of steam engine, supposing that a possible zero of temperature could be attained? This may be done by assuming that instead of stopping the expansion at a point at or near the atmospheric or condenser pressure, it be continued indefinitely; it will, however, be readily seen that in order that the expansion may thus be continued, it would be necessary, in the first place, to have a cylinder of infinite length that the steam may be expanded down to zero pressure; and second, the cylinder and piston must be absolutely non-conducting, as otherwise the heat of the surrounding atmosphere would pass inside and prevent the absolute zero from ever being reached.

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* See page 136.

As expansion proceeds it will also be seen that the pressures become very low near the end, being approximately zero. In other words, in order to utilize the few pounds of pressure between the usual condenser vacuum and a perfect vacuum (corresponding to absolute zero), the usual steam cylinder would have to be made infinite in length and the piston at the lower rates of expansion would have to travel miles in stroke to develop work at the rate of but the merest fraction of a horse power.

To arrive at a rational basis for determining the real efficiency of the steam engine, it will only be necessary to bear in mind a few simple principles. First, that the amount of heat in a pound of steam exhausted from an engine is less than that contained in the same pound of steam when entering the cylinder. Second, that the difference between the heat in the entering steam and the heat in the exhaust steam is the amount which in the perfect engine would be turned into mechanical work, or horse power; or perfect

$$\text{efficiency} = \frac{\text{entering heat—exhausted heat}}{\text{entering heat}}.$$

Third, that the actual practical efficiency of a steam engine is the ratio of the horse power which it actually develops from a given amount of coal, to the horse power that the perfect engine would develop from the same amount of coal.

To obtain, therefore, the practical efficiency of a steam engine working under given conditions, it will be necessary to find, for example, the coal necessary to develop a horse power hour in a perfect engine and compare it with the amount actually used per horse power hour in the engine under consideration. To make more clear and simple the method by which this may be done, we will take up a particular case—that of a triple expansion engine working at 175 lbs. pressure above a vacuum (160 lbs. gauge), and exhausting into a condenser carrying a vacuum of twenty-six inches (two pounds back pressure). Furthermore, we will assume that such an engine may develop in actual work, an indicated hourly horse power on 1.4 lbs. of coal.

The absolute temperature of the entering and exhausted steam under the above pressures is 830 degs. F. and 586 degs. F., respectively, as may be determined from any steam table. Now it happens that the expression for perfect efficiency,

$$\frac{\text{entering heat—exhausted heat}}{\text{entering heat}}$$

may be replaced by the expression,

$$\frac{\text{entering absolute temperature—exhaust absolute temperature}}{\text{entering absolute temperature}};$$

therefore, the perfect efficiency in the case of the engine under consideration $= \frac{830-586}{830} =$ 29.4 per cent.

That is to say, out of the heat in each pound of steam supplied to a perfect engine working between the above limits of pressure, only about 29.4 per cent. can be utilized under the conditions which prevail in our planet; furthermore, with a boiler efficiency of seventy per cent., we may say that only $29.4 \times .70 = 20.58$ per cent. of the heat contained in the coal burned in the furnace of such a boiler can, in the world in which we live, be transformed into power in a steam engine working between the above limits under even perfect conditions—which conditions, of course, can only be approximated in practice. In other words, of one hundred pounds of coal fed to the furnace of a good boiler, the heat of only 20.58 lbs. is available for transformation into mechanical work between the limits of pressure which have been here assumed, and which limits correspond to present practice in efficient working.

Now, since we have assumed that the engine used as an illustration develops an hourly horse power on 1.4 lbs. of coal, for each one hundred pounds of coal used per hour there will be developed

$$\frac{100}{1.4} = 71.4 \text{ HP hours.}$$

Our perfect engine could, as has just been shown, utilize 20.58 per cent. of the 100 lbs. of coal, or 20.58 lbs. A pound of good coal contains 14,000 heat units, so that 20.58 lbs. will contain 288,120 heat units. On the other hand, a HP minute is equivalent to 33,000 ft. lbs., or since there are 772 ft. lbs. to a heat unit—to 42.7 heat units; consequently a HP hour is equivalent to 2562 heat units. Dividing 288,120 by 2562 we have, finally, 112.4 HP that would be developed with 100 lbs. of coal, in our perfect engine, or, in other words, if the steam were worked with no preventable losses or at perfect efficiency.

From the above it follows that the practical efficiency of the engine considered is $\frac{71.4}{112.4} = 63.5$ per cent.—a figure quite different from the twelve or thirteen per cent. upon which popular writers base their wails, and an efficiency which will be recognized as a fair one for a good many machines other than the steam engine.

As the frictional efficiency of steam engines may be as high as ninety-seven per cent., it will be seen that the only room for improvement in general lies in increasing the working efficiency of the steam; that is, reducing the margin between 63.5 per cent. and 100 per cent. in the instance above. The loss of thirty odd per cent. is principally from condensation and partly from radiation, leaks, clearance, etc. Watt early recognized the great loss from condensation, and experimented on the subject with wood-lined cylinders, and down to the present day attempts have been made to produce a non-conducting cylinder liner to reduce this principal loss. It would seem, however, that the greatest promise lies in the use of superheated steam. In any event it is not probable that any striking saving will be made at any time in the future with respect to the steam engine, as the 36.5 per cent. margin in the above case will most probably not admit of close paring, owing to the very nature of heat wastes.

Modern Armature Windings and Connections.

BY CECIL P. POOLE.

All armature windings are governed by the fundamental principles stated in the following rules:

1. The wires of each coil or group of coils must lead under magnet poles of opposite sign from opposite directions and under poles of like sign from the same direction, reckoning from end to end of the armature core. 2. The two "sides" of a coil on a drum armature should occupy relatively identical positions under magnet poles of opposite sign at the same instant. 3. When two or more individual coils are grouped in series, the ending of one should connect with the beginning of the next one of the group.

Rule No. 1, more explicitly stated, means that the wires of each coil or group of coils must be so disposed that a current flowing through the coil or group with the armature at rest will pass through each individual wire in the same direction (say, from front to back) under the north pole or poles and in opposite direction (say, from back to front) under the south pole or poles of the field magnet. The term "sides", in rule No. 2, refers to those portions of the coil lying along the core parallel with the shaft. Rule No. 3 is usually rendered superfluous by the observation of No. 1, but it is a convenient reminder in practice and saves constant reference to diagrams.

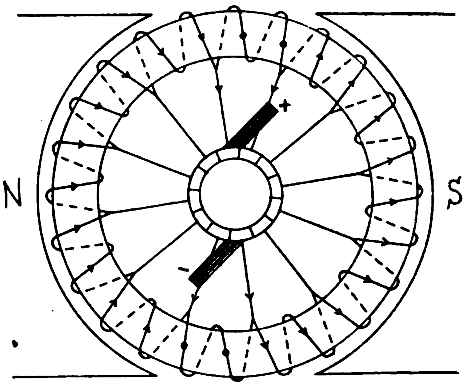


FIG. 1.

Keeping the first two rules in mind, one may devise an almost endless number of combinations, and a goodly number has been advanced within the past ten or twelve years, but the demand of practical engineers for simplicity has relegated all fancy and eccentric winding schemes to historical record, where they do the least amount of harm. Hence, out of several hundred schemes submitted, only about a dozen continuous-current windings have survived in practice. All of these are very slight modifications of the original plan of Pacinotti and that of Von Hefner Alteneck, commonly, but not quite accurately, spoken of as the Gramme and Siemens windings, respectively. These are the simplest possible forms of armature windings, and, as intimated before, are absolutely fundamental in character. Fig. 1 shows diagrammatically the ring winding of Pacinotti and Gramme, and Fig. 2 the drum winding of Von Hefner Alteneck. In these and the succeeding diagrams the coils on the ring armatures have been represented as having two turns each and those on the drum armatures one, for the sake of simplicity. It will, of course, be understood that any practical number of turns may be substituted, the only requisite being that the connections from the coil ends be made as shown. The arrow heads near the periphery indicate the direction of current flow; those coils marked *o* are short-circuited by brushes when they occupy the positions shown, and, therefore, do not contribute to the current flow in the general armature circuits. The ring armature windings shown are designated as left hand windings because, tracing the convolutions from the front to the back end, they lead around the core from right to left; it is entirely immaterial whether the winding is in this or the opposite direction, so far as the efficient working of the machine is concerned; the only effect is upon the polarity of the brushes. With a right-hand winding the upper brush in Fig. 1 would be negative instead of positive in sign.

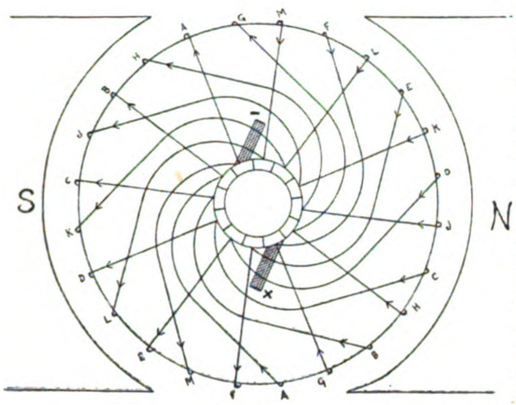


FIG. 2.

The ring winding is easily traced, and index letters opposite the coil ends in Fig. 2 enable one to follow the drum winding without great difficulty; the current entering at the — brush goes half through coil *A*, *A*, coil *B*, *B*, and so on to coil *F*, *F*, from which it passes to the + brush; the other half reaches the + brush by way of coils *MM*—*LL*—*KK*—*JJ*—*HH*—*GG*.

Fig. 3 shows a ring winding identical with that of Fig. 1, but made operative with four magnet poles instead of two by adding two brushes on the commutator. With only two brushes diametrically opposite there could be no current flow, as the current in one-fourth of the winding opposes and equals in power that in the neighboring fourth. The two positive brushes are electrically connected together outside and the two negative brushes are similarly connected. The drum winding shown by Fig. 2 could also be operated in a quadripolar field by adding two brushes, but this winding is very seldom so used, because the one shown by Fig. 4 is much easier to put on and gives a smaller proportion of inductively-idle wire. The difference is that the coils follow Rule No. 2; the two sides of coil *EE* lie under magnet poles of opposite sign or polarity, and as the north and south poles are 90 degs. apart instead of 180 as in a bipolar machine, the sides of each coil are approximately that distance apart. The use in the diagram of very few coils, to simplify inspection, causes the coils to appear distorted; were there shown the usual number commonly employed the upper side of coil *E*, for instance, would occupy a position almost opposite the center of the N pole. The mechanical difference between the coils in Fig. 2 and those in Fig. 4 is greatly in favor of the latter; if the coils are formed first and then put on the core, the 90-deg. coils are much more easily put on or removed, and whether formed first or wound directly on the core, the "piling up" on the ends where the coils cross each other is more uniform and takes less room with 90-deg. than with 180-deg. coils. Where the coils are wound directly on the core the difference between the length of the shortest and that of the longest coils is much less with the 90-deg. winding, giving better electrical proportions and reducing sparking. Fig. 5 shows the back end of an armature core having three 90-deg. coils on one side and three 180-deg. coils on the other; it will be noticed that the former cross each other at a greater angle than the latter, and the different crossings are farther removed from each other. Another advantage possessed by the 90-deg. winding is that there is no tendency of the wires to pull inward against the shaft.

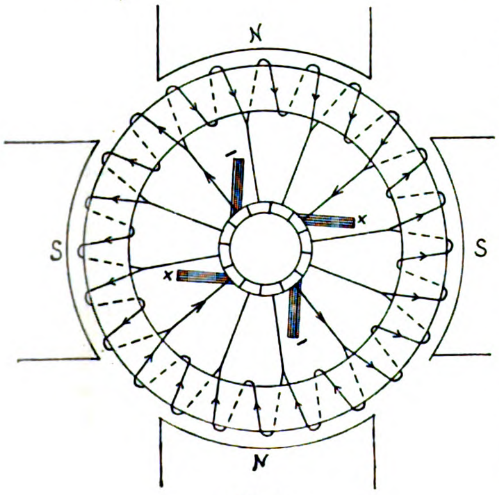


FIG. 3.

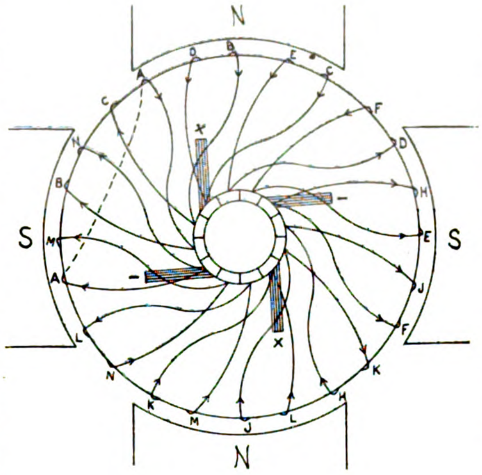
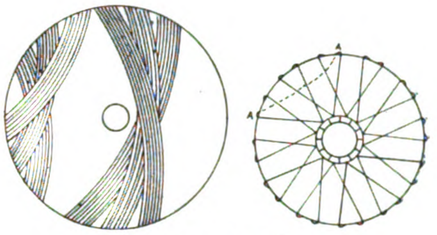


FIG. 4.

Referring again to Fig. 4, the leads from each coil go to neighboring commutator segments, just like those in Fig. 2; there is no particular necessity for carrying the leads so far around the commutator except to carry the brushes around the commutator to the so-called theoretical neutral point. For convenience in connecting up, one end of a coil is usually brought straight out to the nearest commutator segment and the other carried around 90 degs. to the neighboring segment. The plan shown in Fig. 6 is, however, preferable; each end of the coil is led around approximately 45 degs. toward its mate, so that the leads are of practically equal length.



FIGS. 5 AND 6.

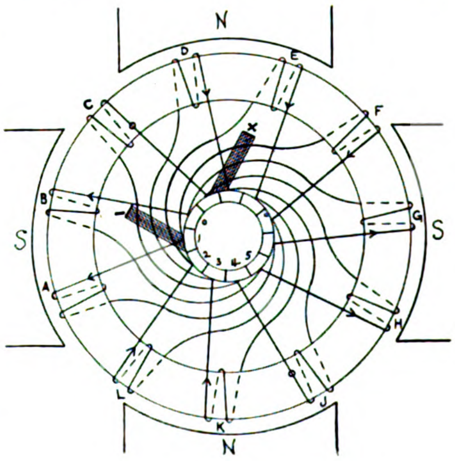


FIG. 7.

In the construction of multipolar machines two-circuit windings have come into universal favor, their chief point of merit being that the magnetic circuits may be entirely unbalanced without the troublesome or disastrous results which would be entailed under such conditions in multi-circuit armatures. The reason for this will be apparent upon inspection of Figs. 7 and 8 which show diagrams respectively of ring and drum two-circuit windings. Here the winding is divided into two circuits each being subjected to the influence of all four magnet poles, the inductive effects in both halves of the winding are therefore identical irrespective of discrepancies in the magnetic circuits. Referring to Fig. 7, it will be noticed that the winding, instead of being a series of unbroken convolutions, as in Figs. 1 and 3, is divided up into distinct coils, the ends of which go to commutator segments almost diametrically opposite each other. It will also be noticed that the number of coils is odd instead of even. The coils of the drum armature (Fig. 8) are identical in form with those in Fig. 4, but the disposition of the commutator leads is different, corresponding with the arrangement shown in Fig. 7. The number of coils on a two-circuit armature must be one less or one more than some (any) multiple of the number of poles on the magnet. The ends of each coil must go to commutator segments whose distance apart in segments equals the total number of bars divided by the number of north poles on the machine, the remainder being ignored. For example, in Fig. 7 there are eleven bars and two north poles; dividing the former by the latter and ignoring the remainder gives the number five. Taking coil *B*, for instance, and counting from the segment to which the straight lead runs, the curved lead is found five segments away. In counting the segments, the one from which the start is made is excluded. This rule applies equally well to two-circuit ring and drum armatures.

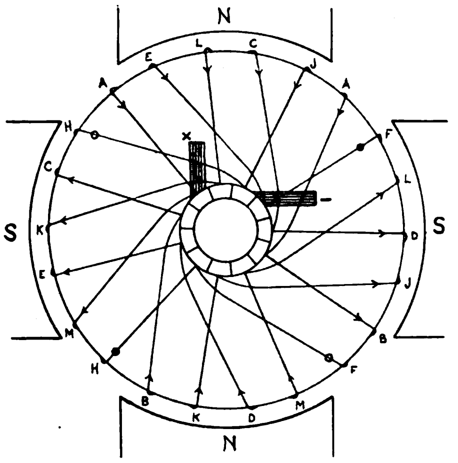


FIG. 8.

An exception to this rule, however, is found in the winding shown in Fig. 9, but the rule governing the number of coils still applies. Here there are twice as many commutator segments as coils, and the ends of the coils are led to adjacent segments, but the ends of adjacent coils are not connected directly together. A system of auxiliary connections is employed to electrically unite *opposite* commutator bars. The diagram shows these connections as though a part of the winding, but in practice they are formed by a nest of spiral copper strips just back of and attached directly to the commutator segments. The leads from the armature winding are brought out to the commutator entirely regardless of these auxiliary connections. The advantages gained by this plan are the reduction of the difference of potential between adjacent commutator segments, and the short-circuiting of only one coil at a time by each brush; in the windings shown by Figs. 7 and 8 two coils are short-circuited by each brush. This winding requires for a six pole machine, *three* times as many segments as coils, and the auxiliary connections unite bars 120 degs. apart instead of diametrically opposite; for an eight-pole machine four times as many bars as coils would be required, and segments 90 degs. apart are connected, and so on.

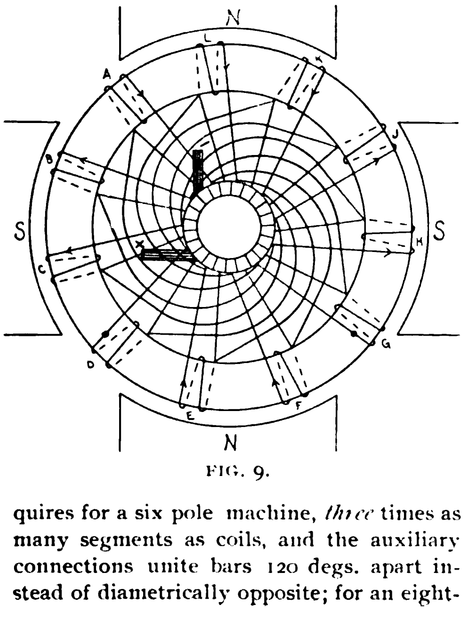


FIG. 9.

The disadvantage of the winding lies in the multiplicity of commutator connections; there are no undesirable magnetic or electrical features provided the auxiliary connectors are given an abnormal cross-section to avoid heating; built up in a nest as they are, they have very little effective radiating surface and get no artificial ventilation worth speaking of. Fig. 10 shows a drum winding which corresponds with the ring winding just described; the same remarks apply to both.

In machines supplying very heavy currents, windings known as double windings have been successfully used with a view to dividing up the current among a greater number of circuits and reducing the potential difference between adjacent commutator segments without using the auxiliary connections of Figs. 9 and 10 and dividing the armature conductors into strands. This method consists broadly of putting two separate and distinct two-circuit windings on the armature core, the coils of one winding alternating with those of the other. A single commutator is used for both windings, the segments alternating in conformity with the coils. Considering each winding separately, it is exactly like either of those shown by Figs. 7 and 8; Fig. 11 shows a double-wound, two-circuit ring. The brushes are made sufficiently thick to cover at least two complete segments, and usually cover about two and a half segments. This puts the two windings in parallel, and the coils of one winding are short-circuited by the brush, while a commutator segment, which is entirely disconnected from the winding, is interposed between the two segments belonging to the short-circuited coils; this very materially reduces the tendency to sparking and enhances the smoothness of commutation. The electrical advantages of the winding shown by Fig. 7 are secured with easier commutation and without the constructional disadvantages of the plan in Fig. 9. The corresponding drum winding consists of two windings like that shown by Fig. 8, put on the core and connected with the commutator as above described. Double windings may, obviously, be applied to any winding plan, the only change being to put on two distinct windings of the plan chosen, double the number of commutator segments and make the brushes of the requisite thickness. There are, naturally, a good many modifications of the windings herein described, and some of them are in limited use in special cases, but the diagrams given cover all the plans of low and medium potential continuous-current windings now in general use in this country.

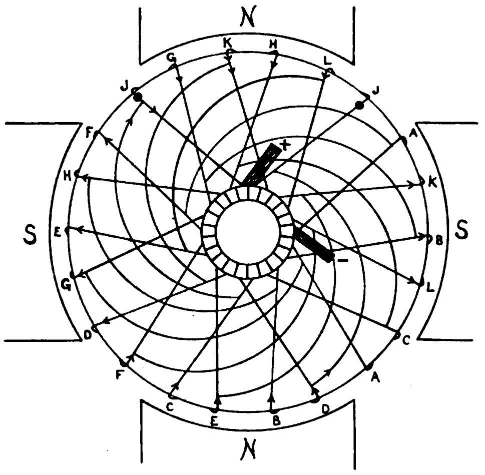


FIG. 10.

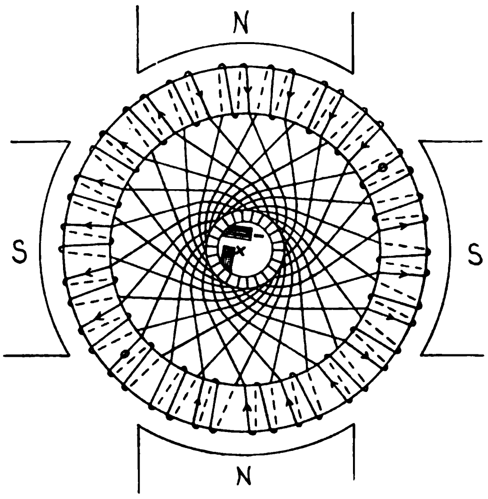


FIG. 11.

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NORTHWESTERN ELECTRICAL ASSOCIATION.

At the convention of the Northwestern Electrical Association held at Marinette, Wis., July 15, 16 and 17, another success was added to the record of this vigorous young organization. While the attendance was not comparable to that of meetings of the several national electrical bodies, this was due rather to the necessarily limited membership, than to any lack of interest in the objects of the association or in the proceedings of its sessions. The secretary reported a large number of new admissions, and indications point to still greater growth and prosperity.

Considerable discussion was held concerning the collection of data from central stations within the territory of the association, and an effort will be made during the coming year to obtain complete data relating to the cost of electric lighting in all central station towns in Wisconsin and contiguous territory in Michigan and Minnesota.

The movement to prevent hostile legislation will be continued, and it was shown that efforts in this line during the meeting of the Legislature in Wisconsin for the last couple of years have been crowned with much success, particularly in preventing legislation unfavorable to the establishment of municipal lighting plants at the expense of local plants.

The most prominent feature of the discussion was a very vigorous attack by Mr. John I. Beggs upon the National Electric Light Association, the main points of which are given below.

President Baker in his address referred to the desirability of continuing the efforts to obtain data concerning the cost of electric lighting from various central stations, in order that members may thereby be enabled to meet false statements designed to influence municipal bodies and the public. It was recommended that a close relationship should be established between electric light and insurance companies, as recently much hardship had been caused by the action of insurance inspectors in condemning wiring.

Secretary T. R. Mercein read a paper on the recent Convention of the National Electric Light Association and the National Electrical Exhibition, at which he represented his association in an official capacity. He referred to the feeling of antagonism between the National Electric Light Association and electrical manufacturers, which feeling, he stated, had not been thus far evident at any meeting of the Northwestern Association. Mr. Mercein pronounced the papers presented at the New York Convention as both too technical and theoretical and not calculated to meet the demand for general practical information. He also considered that the discussions were not spontaneous, and said he was struck by the aggressive manner of those asking information on the subject at hand, there seeming to be a desire to trip up the speaker, and many questions were apparently aimed at his discomfiture. In this respect he contrasted the uniformity of attention and courtesy accorded to speakers before the Northwestern Electrical Association. He also referred to the marked contrast which he found between the free, spontaneous courtesy and hospitality of the West and the comparatively strained conventional manners of Eastern entertainers. Following are abstracts of the papers and disscussions:

INSURANCE OF ELECTRICAL PLANTS.

Two papers were presented on this subject, one by Mr. C. C. Paige, and the other by Mr. R. H. Pierce. The former was a protest against the growing severity of electrical inspection, which in some places had caused the suspension of electrical service. In answer to the question, "Are the changes and improvements demanded by the insurance inspectors necessary to prevent fire and accident?" Mr. Page feels that the answer will be "No," and his opinion is that underwriters' rules for wiring and installing apparatus for both public buildings and residences should be somewhat modified.

Mr. Pierce, in his paper, discusses more particularly the subject of the insurance of central stations, and after considering the several methods of insurance—by stock fire insurance companies, mutual companies and self insurance through securing the maximum safety through the use of proper construction—he pronounces in favor of the first named, stating that the plan of forming central station Mutuals has been weighed in the balance and found wanting.

The third method mentioned, of securing maximum safety and then taking the chances, he considers may be the best in some, but only in very special cases. If the central station plant is so designed, installed and operated as to reduce the fire hazard to a minimum, the stock insurance companies will ask a minimum rate of insurance, which in most cases, will be so small as to be no burden to the owner. The added investment necessary to meet insurance requirements, he believes, will not only be profitable on account of lower insurance premiums, but also through involving a smaller chance of interruption to service, less repairs and smaller depreciation. The present rules, formulated by the Underwriters' National Electric Association, were spoken of as representing much thought, investigation and experience. In conclusion Mr. Pierce sums up by saying that the solution of the insurance problem is in intelligent construction and operation, and that the way to determine how to design, install and operate plants and how to improve existing plans, is to carefully study and freely discuss the requirements of the Underwriters' National Electric Association as adopted by the various insurance bodies, and then apply the right principles and methods to the plants, both in design and operation.

In the discussion on the above papers, much complaint was made concerning the recent action of insurance inspectors in requiring old wiring to be made to conform to the latest rules. One of the speakers protested against the rule concerning "fishing wiring," and another declared that one State inspector did not know the ordinary distinctions and differences between wiring.

Mr. Cuno took a more favorable view of the situation, and said that the worst trouble was rather in the constant changes in the rules rather than in their severity. He thinks it is the safest way for every central station to do the work in strict conformity with insurance rules, and that a good job is a credit to both the electrical company and to the community, and obviates trouble.

TWO-AND-A-HALF-WATT LAMPS.

Mr. C. J. Buckley addressed the convention on the subject of 2½-watt lamps, his argument being that it was simply a question whether a central station man should continue to use and burn low efficiency lamps on which the manufacturers made a considerable profit, or whether the manufacturers would have to get themselves together and increase their investment and make a lamp upon which central stations could make a profit. He believed that the lamp manufacturers should be required to made a lamp that will give customers a higher candle power and better service; that will increase the capacity of stations to make money, and and not, as at present, let the profits rest entirely with the lamp manufacturers.

Mr. Beggs stated that the Edison Companies had made a formal proposition to lamp manufacturers as follows: Acceptance of lamps to be based upon a test of one lamp from each barrel, the test to run for 600 hours under an expert appointed by the several lighting companies; that for each five per cent. which the lamp falls below the standard, there shall be deducted ten per cent. from the price of the lamp, and that if the lamp is ten per cent. higher than specifications, five per cent. more shall be paid for it, which increase shall be continued until it reaches one hundred per cent. more than the specifications require, when fifty per cent. more shall be paid. Every lamp shall be run until it drops to 12.2 CP, when the life of that lamp shall be considered ended. Mr. Beggs believes that it is a very difficult thing to produce a good 2½-watt lamp, though some lamps of the type to which he had reference, had been made that burned for 1,000 hours. It was not known what caused this long life, it being a mere accident, but it showed that the elements were there, and the effort should now be to discover what these are.

NATIONAL ELECTRIC LIGHT ASSOCIATION.

Mr. John I. Beggs, in the discussion of the paper of Secretary T. R. Mercein, referred in very unfavorable terms to the present condition of the National Electric Light Association, which he declared simply exists at present to make a "fat position" for one man. He stated that he has challenged the National Electric Light Association to show a single thing it has ever done for the benefit of central stations, and the challenge still remains open. He condemned the lack of action concerning the encroachment of the manufacturing companies in lighting fields, stating that the committee appointed for that purpose had not convened since it was named, fifteen months before the New York meeting. He did not know of a single thing done at the recent meeting of the National Electric Light Association which would interest any representative of a central station anywhere in the United States; that scarcely any resolutions passed by that association amounted to anything, because its membership is too meagre and unrepresentative; "they do not represent anything of importance, I say advisedly; they represent a few large companies in a few large cities, but the large companies in the large cities are in many instances controlled by the very people who are interested in exploiting apparatus." Mr. Beggs said he had attended four meetings of the National Association, had labored in season and out of season trying to make it an active, aggressive body laboring in the interest of electric lighting generally, but that all of his efforts had been without avail. The example of the Northwestern Electric Association had led him to believe that local or sectional organizations were much more valuable than the National body under discussion. To illustrate the slackness of the methods of the officers of the Association, Mr. Beggs said that he had presented a resolution, which was unanimously and enthusiastically passed, to print at once a valuable paper which was presented at the New York Convention; and that while there was no reason why the paper should not have been distributed before the close of the Convention, yet he did not receive a copy of it until over two months after the close of the meeting, although the paper was only six or eight pages long.

THE RIGHTS OF ELECTRICAL COMPANIES.

In a paper with the above title, Mr. W. Clyde Jones, of the Chicago Bar, gave a resumé of the legal principles governing the use of the streets and highways for electrical purposes.

After discussing the case of the electric railway, it is stated that the question as to whether or not trolley poles and wires introduce a new servitude has been a hard fought battle, resulting in a decision in the affirmative in some of the states and in a decision in the negative in other states. The most approved tendency, however, is toward the view that the electric street railway with its auxiliaries of poles and wires does not impose upon the street an additional burden for which the abutting property owner must be compensated.

With respect to electric lighting wires and poles, since the same conductors are also employed for supplying current to street lamps it was argued that this was a public necessity and therefore a proper use of the street. Where the plant is owned by the municipality the placing of the poles and wires in the street has been held to be a proper use, imposing no new burden. Where the plant is owned by private parties, though used for street lighting, some courts have held the use of the streets to be a proper use, while others have held to the contrary. Where private plants have been used for private lighting only, there has also been a division of opinion. The tendency of decision, however, is toward the view that the use of the street for electric light wires is a proper use of the street, not imposing a new burden on the street such that abutting property owners must be compensated.

The telephone, since it calls the streets into service for its pole lines, has been attacked on the same grounds as the telegraph, since the telephone is but one form of telegraph. The argument may be made with more force, however, that the telephone assists in the use of the street for transportation purposes, since the many telephone conversations relieve the streets of the passage of the individuals who would otherwise have to meet in order to hold the conversations. The tendency of decision is, nevertheless, toward the view that the telephone, like the telegraph, imposes a new burden on the street for which the property owner is entitled to compensation.

Concerning injury to underground piping from electrolysis produced by electric railway return currents, it is a well established doctrine that every one should so use his own as not to interfere with the rights of others, and it would therefore seem to be the duty of the electric railway companies to so operate their systems as not to interfere with mains laid in the street, and if the use of the ground circuit is essential, to devise some means to prevent deleterious action upon the pipes. A number of methods have been proposed which are claimed to prevent the destruction of the pipes, and if this be the fact, the question arises whether the courts will not hold the electric railway companies responsible for damages done to the mains when it is within their power to prevent such damage by the employment of available means.

ALTERNATING CURRENT MOTORS.

The most interesting paper, from the technical standpoint, read at the meeting was one by Prof. Dugald C. Jackson, giving an account of some comparative tests of alternating current motors made last winter by Messrs. J. H. Perkins and W. H. Williams in the laboratory of Wisconsin University. Five horse power, alternating current motors of the following makers were tested: Fort Wayne Electric Corporation—two-phased; Stanley Electric Manufacturing Company—three-phased; Westinghouse Electric & Manufacturing Company—two-phased; General Electric Company—three-phased.

A 5-HP, three-phased motor made by the Allgemeine Electricitäts Gesellschaft, of Germany, was also included in the tests, and results of tests on machines made by the Oerlikon Works and by C. E. L. Brown, of Switzerland, were obtained. A 10-HP Westinghouse two-phased motor was also tested. A capacity of 5-HP in the motors to be tested was chosen, as that may be considered to be near the average capacity of motors used in the service of ordinary central stations. The results of the tests may therefore be accepted as representing, for the central stations, comparative results between the average motors which they may use on alternating current systems, and the results may also serve as a basis for comparison between average conditions of operating with continuous current and alternating current motors.

When Silvanus P. Thompson wrote his book on polyphase currents, in 1895, he set forth as the requisites for a good alternating current motor that: 1. It shall exert a good torque at starting; 2. It shall be capable of running at a nearly constant speed at all loads; 3. It shall yield in mechanical power a high percentage of the power put into it—that is, it shall have a high commercial efficiency.

There are three additional requisites which Prof. Thompson overlooked, but which determine to fully as great an extent the success of the motor. These are: *a*. The motor shall have a high power factor; *b*. It shall not require an abnormally large current from the lines at the instant of starting. *c*. It shall not cause a large unbalancing of the pressures on the lines of a polyphase circuit.

The requisites, *a*, *b* and *c*, are so important that if they are overlooked, a motor cannot give satisfaction to the central station man, however completely Prof. Thompson's requirements are fulfilled. The last two requisites are especially important where the motors are to be supplied directly from the lighting circuits.

In order to determine how far the alternating current motors in the market fulfill these essential requirements of a machine which will give satisfaction when operated on the circuits of a central station plant, Messrs. Perkins and Williams made tests of the following points:

a. Starting torque and current; *b*. Speed regulation; *c*. Commercial efficiency at all loads; *d*. Power factor at all loads; *e*. Starting current; *f*. Effect on the line pressures when starting.

The measurements were made by the following methods:

a. The power absorbed by the machine was measured by indicating wattmeters, the two-wattmeter method being usually employed.

b. Currents and apparent watts were obtained from the readings of ammeters and voltmeters *in each circuit*.

c. Outputs were measured by a special self-adjusting Prony brake which proved to be entirely reliable.

d. Disturbance of the circuits upon starting the motors was determined by observing the action of incandescent lamps connected to independent transformers, and by voltmeter readings of the pressure on the lines.

e. The torque which the motor could exert when starting ("static torque" of the recapitulation) was measured by clamping the brake up tight and then balancing the pull of the motor. This is by no means the starting torque of the polyphase motors (that is, the torque corresponding to the load which the motor is capable of pulling up to speed), unless the armature starting resistance is subdivided. In only one of the polyphase motors tested was this the case, and all the others showed a starting torque below the maximum running torque. The results of the tests are clearly shown in the accompanying table and set of curves.

Four out of the six motors tested affected the incandescent service disastrously, and showed the absurdity of attempting with them a combined service on the same circuits as the incandescent lighting in those plants where regulation and the satisfaction of the customers is considered of importance. The tests show that the alternating current motors give a regulation and efficiency equally satisfactory to that given by continuous current motors, but the power factors of most of the machines are small for part load, the starting currents excessive, and the starting torques with the present arrangement of starting resistances are unduly small.

RECAPITULATION.—COMPARATIVE QUANTITIES.

No.	Rated Capacity, H. P.	Rating of Voltage Used, H. P.	Torque, in % of Full Load.			Starting Current, in % of Full Load.	Drop in Speed at Full Load, %	Efficiencies, %					Power Factors, %					
			Max. Running	Static.	Starting.			Max. Eff.	¼ Load.	½ Load.	¾ Load.	Full Load.	Max. P. F.	0 Load.	¼ Load.	½ Load.	¾ Load.	Full Load.
1	5	5	140	131	77	157	3.	77.8	55.2	70.6	77.	76.6	76.4	13.	37.5	50.	62.3	71.5
2	5	5	100	45	44	153		83.8	54.5	72.5	80.5	83.8	67.5	10.5	25.5	58.	67.3	64.
3	5	6.26	104	90	83	114	9.7	79	52.	71.9	78.9	77.	84.	74.	81.6	83.3	83.7	84.
4	5	5	186.5	136	39.4	262	7.	79.5	62.2	77.2	79.5	77.8	82.6	15.5	44.7	62.5	73.7	80.3
5	5	6.55	171.	138.5	86.6	156	3.7	88	75.2	85.	87.7	88.	78.5	6.8	27.5	45.5	59.8	70.3
6	10	10	>147	142	137	194	4.5	82	67.	78.4	81.9	81.1	79.	15.	40.4	59.1	69.	73.4
7	4.5	4.5	>163	232		357	3.7	79.1	61.	73.8	78.4	79.1	88.4	22.2	51.3	69.4	80.3	85.2
8	5	5					4.6	83.8	65.5	80.2	83.8	82.	89.		52.	71.5	81.7	87.2

NOTE.—Nos. 6, 7 and 8 were not run up to maximum load, on test.

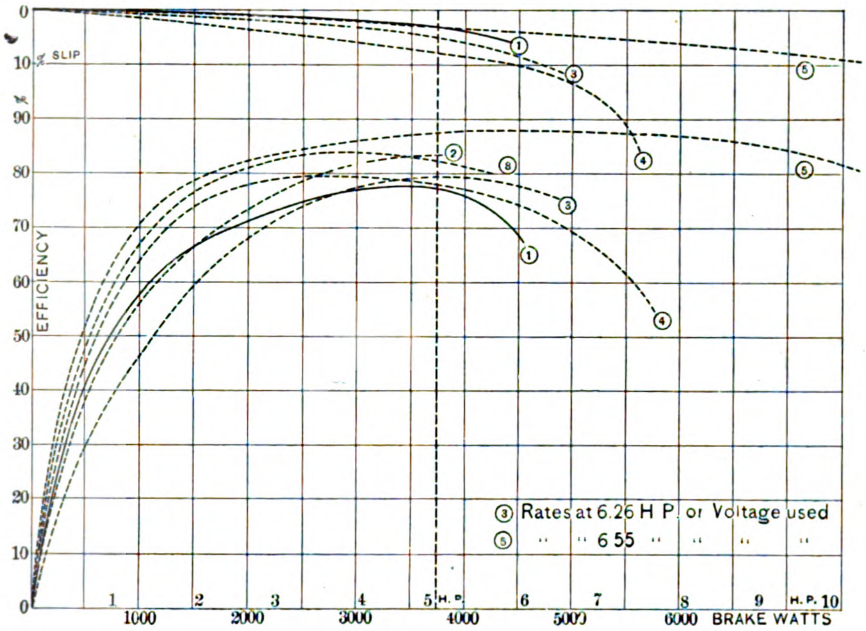
The best performance of the American five-horse-power machines lies between No. 3 and No. 5 of the tables. These machines will stand well above the others. They are about even in starting torque, but No. 5 will carry considerably the higher load before dropping out of its pace; No. 5 also regulates the better and has the higher efficiency. On the other hand, No. 3 has a power factor incomparably better than any of the other machines. The question of efficiency and power factor affects the central station as follows:

1. As power is (or at least always should be) sold by meter, the consumer pays for the losses of his motor, and it is of interest to

the central station that the motors have a high efficiency only in order that a fair price per kilowatt hour delivered to the customer may not prove to convert into an excessive or even prohibitive per horse power hour, net, which is delivered by the motor to the customer's machinery.

2. On the other hand, the power factor strikes the central station directly; since a low power factor causes an increased current output, with an accompanying increased loss in the lines and transformers, and, even worse, with a demand for an excess capacity and therefore of cost in the generating machinery and transformers.

Supposing that the average load that may be assumed to be carried by a 5-HP motor is 3½-HP, which is ordinary service; then the average efficiency and power factor of motor No. 3 are 75½ per cent. and 83½ per cent. and of motor No. 5 are 85 per cent. and 59 per cent. In other words, the central station must install over 40 per cent. greater capacity in generators, lines and transformers to supply a given power service to motor No. 5 than would be necessary if motor No. 3 were used. This difference appears to wipe out the difference of 10 per cent. in efficiencies. In other words, the central station owner supplying power to motor No. 3 could probably afford, if necessary, to sell his power at enough lower price per kilowatt to make the customer's horse power of the same cost as if supplied by motor No. 5, and yet make more money and have better regulation on his plant.



CURVES OF TESTS OF POLYPHASED MOTORS.

The question of power distribution for alternating current stations, *as it now stands*, resolves itself into this:

1. If you have a 500-volt continuous current power service, stick to it.

2. If you can develop a large power service within a radius of two miles from the station, put in a 500-volt continuous current outfit.

3. If you can develop a small power service only, which cannot afford a duplication of apparatus, or your distances are excessive, then arrange to use alternating current motors.

4. In this case, arrange to operate all the lamps on one phase to avoid, as far as possible, difficulty in regulation, and install such a generator and system of lines as will enable the use of motors.

5. Motors intended for such use should be guaranteed to have a high power factor and to start without taking an excessive current from the lines.

6. Never use recording ammeters with alternating current motors if you really intend to develop a power service, but use recording wattmeters to indicate the power absorbed by the motors.

7. Where two-phase or three-phase motors are used, place two recording wattmeters, properly connected, to indicate the total power by summing their readings. (A single special meter, made up to serve the purpose of the two may be used, but such an instrument is not now on the market.

This summation is based on the assumption that uniformity of pressure at the lamps is valued by the central station man. Carelessness in regard to regulation is one of the features which has militated against the financial success of many alternating current stations, and its importance should be borne carefully in mind when considering the advisability of a combined light and power service. The lighting is generally the most important service to the station, and nothing should be done to injure its regularity and reliability.

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The Good Old Times.

In an address delivered before the recent convention of the Northwestern Electrical Association, Mr. John I. Beggs illustrated the difference between former and present methods of selling electrical machinery, by the statement that in the "Good Old Times," half the purchase price was taken in cash and half in bonds, and as the cash consideration was twice the cost of the apparatus sold, the bonds were used by the selling agents for lighting cigars as they left the town!

220-VOLT LAMPS.

By CONVERSE D. MARSH.

Although high-voltage lamps were used experimentally in two stations in this country for several years, they were not practically employed until Mr. W. N. Stewart, of Minneapolis, representing the Siemens & Halske Company, applied to my company for a 220-volt lamp with which to compete with the Edison three-wire system. The number of successful plants now installed and running attest the complete victory of the high-voltage system in central stations of moderate size operating over somewhat scattered territory. Following in our wake many attempts have been made to produce a standard of 220-volt lamps, consisting of a single filament supported in the middle of its length. We are now able to produce these lamps at an efficiency slightly below four watts per candle power, and their excellent life is well shown by the many expressions of approval we have received.

Not only are they used by central stations, but many power plants running on a voltage of from 200 to 550 are employing them. We have made them up as high as 260 volts.

Reports from users indicate that alterations in wiring are inconsiderable. Strange as it may appear, the breaking of the arc by key sockets is more successfully done with 220 volts pressure than with 110, the long-drawn yellow flame being succeeded by a short blue spark when the circuit is interrupted.

Our lamps have been in active use since the summer of 1894, and we attribute our success in their manufacture at such a comparatively early period to the fact that our workman to whom the chief steps in the manufacture were entrusted, had experience in the production of high-voltage lamps dating back to 1891.

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HIGH-VOLTAGE INCANDESCENT LIGHTING.

We are enabled to present herewith reports from a number of central stations and lighting plants using 220-volt lamps, from which it will be seen that the experience with high-voltage working in this country has been no less satisfactory than abroad.

Mr. Andrew King, superintendent of the Edison-Allegan Light & Power Company, Allegan, Mich., which was one of the earliest central stations in this country to adopt 220-volt lamps, writes as follows:

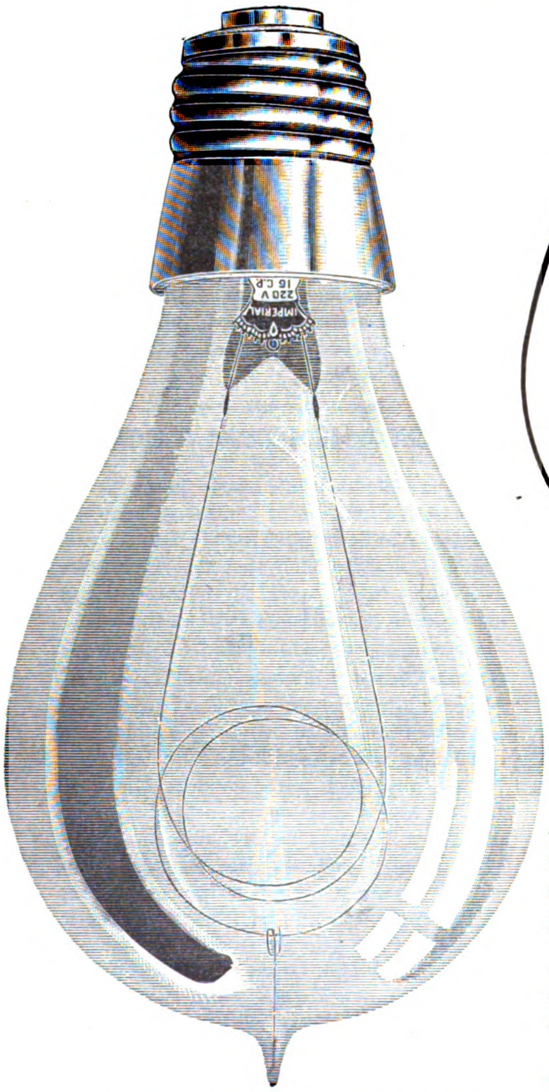
"We have had fairly good results from 220-volt lamps, and we are now displacing the 110-volt lamps as fast as practicable. There is no change required in the fittings except, of course, to change the connections on the three-wire system from 110 volts to 220 volts. The greatest trouble at first met with was through short circuiting in the lamp base, and the drooping of the filament when the lamp hung at an angle, which caused it to touch and crack the glass; these objections are now being overcome to a great extent, and it is safe to say that all the low-voltage lamps will soon be replaced by those of 220 volts."

Mr. Frank A. Moss, chief engineer of the Ontonagon (Mich.) central station, which uses 220-volt lamps exclusively, states that he finds the high-voltage system entirely satisfactory and preferable to low-voltage working.

Mr. C. M. Morgan, superintendent of the Preston (Minn.) Electric Light Works, says that at present the central station at Preston is not entirely completed, and while he therefore cannot make a statement based upon actual working, he is satisfied from the study given to the subject before deciding upon the 220-volt system that it will give entire satisfaction.

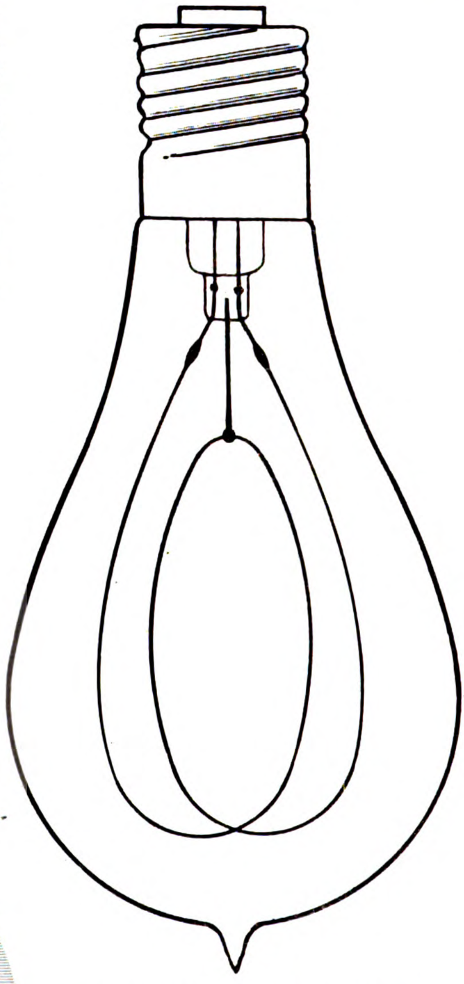
Mr. R. M. Hiskett, superintendent of the Ft. Howard (Wis.) central station writes as follows:

"We have the two-wire, high-voltage system using 220-volt incandescent lamps and burning arc lamps four in series from the same machine. We have found the 220-volt lamp fully as satisfactory as those of lower voltage, both in life and in maintenance of candle power. Some makes of lamps having long slender filaments require careful handling to prevent short circuiting, and all, of course, are of lower efficiency than low-voltage lamps, ranging from 3½ to 4 watts. We have found it necessary in nearly all cases to materially alter interior wiring installed for low-voltage lamps before substituting 220-volt lamps. The ordinary fuse rosettes, plug cut-outs, smaller cut-outs and short-break switches, etc., are unfitted for 220-volt circuits, as they arc badly, burning the contacts and cracking the porcelain. Nothing but cut-outs with long fuses, and quick, long-breaking switches, can be used. Altogether our experience with the 220-volt system has been most satisfactory, and under the same conditions we would not want to install any other."



IMPERIAL 220-VOLT LAMP (Full size).

The El Reno (O. T.) Electric Light Company has been operating a direct-current, 220-volt system and at first experienced some trouble in getting good lamps. Mr. Wm. Richards, president of the company, writes that "From the day we started until July 25, our engine varied forty-eight revolutions per minute when twelve arc lamps were thrown on, consequently the voltage had to be watched and regulated constantly. But in the face of this sudden and severe fluctuation, with "Imperial" 220-volt lamps the hardship thus imposed has been withstood better than with any of the other makes. The Imperial lamps are as much more efficient as to life, candle power and current consumption as is the Corliss engine we have just started over the engine replaced."

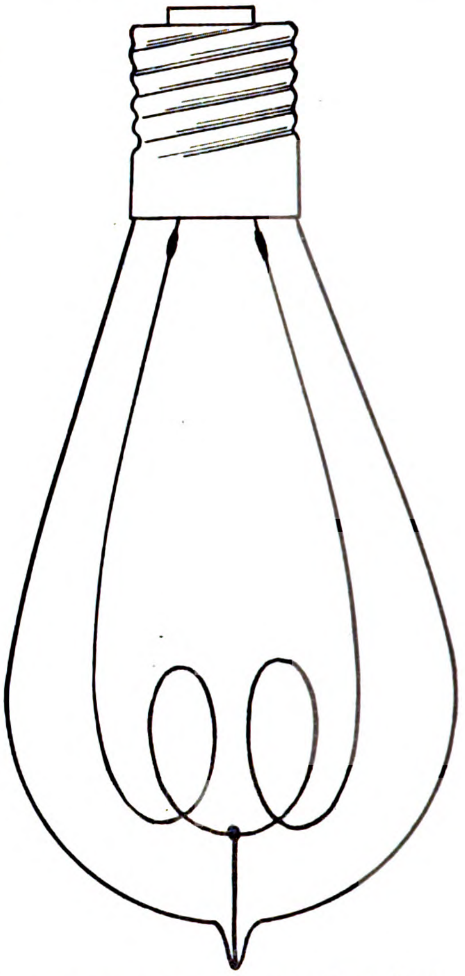


EDISON 220-VOLT LAMP (Full size.)

Mr. Thomas G. Smith, Jr., Cincinnati, O., who as consulting engineer had charge of the design of the Norwood (O.) central electric lighting station writes as follows:

"Our experience in the use of 220-volt incandescent lamps has not been of such length as to enable us to speak with certainty born of long acquaintance with the subject; however, we are certain that our experience so far has been very satisfactory. We find that the 220-volt lamp will stand a greater range of voltage than the 110; in fact, we have had 220-volt lamps burning for a considerable period of time on as high as 265-volts, without signs of distress.

"The principal load on the Norwood station at present is about 150 constant-potential arc lamps for street service; the incandescent load has not been taken on, except about twenty lights in the station building; I believe an examination of this station and the system in use, would be of interest to many of your readers in this section, and I am sure they will be welcomed at any time.



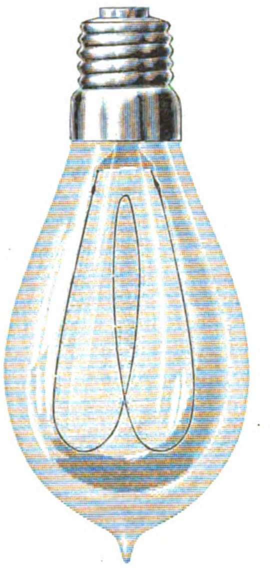
COLUMBIA 220-VOLT LAMP (Full size.)

"The experience in the operation of this station, up to date, has been a direct refutation of some of the most plausible and presumably sincere statements made by representatives of some of the leading electric manufacturing companies."

Mr. S. Kirlin, electrician of the Montevideo Roller Mills, Montevideo, Minn., states that the 220-volt plant in his charge has been in operation only since last winter, but during that period it has been highly satisfactory in every respect. "We are using the 'New' Edison type lamps, and find that they give excellent service on this system, some of them having burned over 1500 hours, and are still giving good service. Every one who has seen our plant says that the light is superior to any they have seen elsewhere. I believe that the 220-volt system for lighting and power, for reasonable distances, is the coming system."

Mr. Joseph Kenney, chief engineer of the New York Custom House, states that his experience with 220-volt lamps has been very satisfactory. 1600 lamps are installed in the Custom House, and of these an average of

600 have been in use daily since February. Many of the original lamps ("New" Edison type) are still burning in places where they have been constantly in circuit for over 1400 hours, and these show but little diminution in candle power. The fittings are the same as were used when the Custom House was lighted from a 50-volt alternating commercial circuit, and no trouble has been experienced, though the ceiling rosettes, of which many are in use, are of an exceptionally small size. Two 75-KW generators are installed, one being held in reserve; two Sprague elevators are run from the same bus bars as the lights. Mr. Kenney considers that the adoption of the 220-volt system for the Custom House was a wise measure, and predicts that the high-voltage system of lighting will rapidly extend.



SUNBEAM 220-VOLT LAMP (Half size).

Mr. H. S. Patten, electrical engineer of the New York Heat, Light & Power Company, states that 220-volt lamps have been used on some of the circuits of his company with considerable success, and will probably be introduced on all circuits when proper fittings come on the market, and assurances are received that satisfactory high-voltage lamps can be secured at all times in sufficient quantities. The only drawback thus far experienced in the use of the lamps has been on account of fittings. The fuse blocks on low-voltage circuits have not been found suitable for 220-volts, and as yet no substitutes are regularly on the market.

A manufacturer of high-voltage lamps writes as follows:

"Regarding 220-volt lamps, or, to speak more generically, the 220-volt lamp, I can say that the manufacture of these lamps in accordance with a small demand from customers, commenced about four or five years ago. The first lamps were, of course, more or less unsatisfactory, it being a new development, and the lamp itself difficult to manufacture. Since that time, the quality of the lamps manufactured has gradually improved, and the demand for them has steadily increased. The total output of these high-voltage lamps is still small in comparison with standard lamps of from 100 to 125 volts, but the customers who are using them find greatly increased satisfaction since their first introduction.

"Some of the obstacles to the use of 220-volt lamps are, first, the fact that cut-outs, switches, etc., for this high voltage have not yet been developed, and consequently the lamps have been used with the 100-volt fittings; second in regard to the manufacture of the lamps themselves, the filament is of necessity a long and slender one, and cannot be 'treated' to the same extent as the stouter standard filaments. Were manufacturers to attempt marketing a 200-volt lamp of the same efficiency (three watts per candle) as the 100-volt lamps, the filament would be so exceedingly fine that its stability, and consequently its life, would not be satisfactory. These high-voltage lamps, therefore, for the present at least, will be handicapped by being of a somewhat lower efficiency than standard lamps."

NIAGARA POWER AT BUFFALO.

By Nov. 4 next, the cars of the Buffalo Railway Company will be driven by electric power generated at Niagara. The two-phased system of transmission will be employed, the two-phased currents at the generators being transformed to three-phased currents and the voltage stepped up at the same time. The contracts were made between the Cataract Construction Company, supplying the electricity, and the General Electric Company, and between the latter company and the Buffalo Power & Conduit Company controlling the supply and distribution of Niagara electric power in Buffalo, and the Buffalo Railway Company. The contracts provide for all the apparatus and machinery necessary for the transformation up, transmission, transformation down, conversion and delivery of 1000 HP to the overhead wires of the Buffalo Street Railway system.

The contract with the Cataract Construction Company covers three of the air blast type transformers. These will be the largest transformers ever constructed, and will step-up the Niagara 2200-volt, two-phased currents to either 11,000 or 22,000 volts three-phased. Any two of the transformers together will deliver 2500 HP.; the third is a spare one. It is the intention to commence transmission operations at 11,000 volts, and later to increase the capacity of the transmission system by increasing the potential to 22,000 volts, for which pressure the transformers will be designed and insulated. The pole line will be erected by the White-Crosby Company, and will have a capacity sufficient to transmit 40,000 HP. This line will run from the transformer house at Niagara Falls along the two mile line road near the track of the New York Central and Erie Railroads, will cross the creek at Division Street, and from Tonawanda to the Buffalo city line will follow the canal banks.

For transforming the power down and converting it into that suitable for street railway purposes, the Power & Conduit Company will use four static transformers of about 360 HP each, and two 500-HP rotary converters. The transformers will reduce from the line potential of either 11,000 or 22,000 volts to 400 volts, at which voltage the three-phased currents will be turned into rotary converters, and then converted into direct railway current of 5500, volts. These transformers and converters will be set up in the Niagara Street power station. The latter will be compound wound, and will operate in multiple with the steam driven generators supplying the balance of the power necessary for the operation of the railway system. They will be of the iron-clad type with steel frames, with collector rings for the three-phased currents at one end, and a commutator for the direct current at the other. They will have six poles and will run at 500 r. p. m., and are similar to that placed in the Niagara power house to furnish current to the Buffalo & Niagara Falls Railroad.

NATIONAL ELECTRIC LIGHT ASSOCIATION.

President Nicholls of the National Electric Light Association in a recent report gives an account of the work that has been accomplished under his administration since the May convention. All of the larger electric manufacturing companies have been communicated with in regard to the matter of their agents assisting movements looking to municipal ownership, and satisfactory assurances were received from all except one company, not only with respect to the particular case to which the communication referred, but also as to a general policy for the future that will not countenance rendering aid in attacks on private interests. Correspondence has been instituted with municipal authorities of each city and town in the United States with the object of securing, from official sources, statistics relating to the number of arc lamps in use, the CP-hours of burning and the cost of a lamp per night, and a preliminary report accompanies the president's communication giving the above information for 400 cities and towns, the list covering a large majority of the principal installations. The Secretary of State of each of the States in the Union has been communicated with, with a view to making arrangements to have regularly forwarded to the Association copies of all the bills introduced in each State that may deal with the rights of electrical companies. A large majority of the States have acceded to the request, and all bills thus far received are on file in the secretary's office. The report of the recent Convention is stated to be in the printer's hands, and will be delivered to members not later than Sept. 1. The record thus far made by President Nicholls is an enviable one, and the Association is to be congratulated upon the energy and ability displayed by the present executive head in carrying out its objects.

INCANDESCENT LAMP COMBINATION.

For some time past a report has been current that a number of the larger incandescent lamp companies of the country have entered into a combination to regulate competition and to increase the price of incandescent lamps to twenty cents. This report has not yet been confirmed, but it is known that negotiations have been under way for some time, and rumored that a preliminary arrangement has been decided upon, but not yet formally put into effect.

NOTES.

Electric Motors in Iron Works.—At the Carnegie Iron Works at Pittsburg, there are in use more than 200 electric motors, ranging from 5 to 100 HP capacity, and aggregating in the neighborhood of 3000 HP.

A Golden Anniversary.—The *Scientific American* has commemorated its fiftieth year of existence by the issue of a handsome special number giving a review of the development of the industrial arts in the United States during the past half-century. Electrical achievements are chronicled in a series of articles entitled "The Telegraph," "The Submarine Cable," "The Telephone," "The Phonograph" and "The Electric Motor." Among the illustrations of historic interest are cuts of Morse's pendulum instrument of 1837 and his telegraph of 1844, Edison's first phonograph, the early forms of the telephone and electric motor, etc. Our esteemed contemporary, the Nestor of American technical journals, has lost nothing of vigor through age and, we hope, will continue to grow in prosperity.

Sir William R. Grove.—That the inventor of the Grove battery was until recently still alive was doubtless a surprise to those who read the notice of his death, which occurred in London, Aug. 2, at the age of eighty-five. Though known best in electrical circles as the inventor, in 1839, of the Grove battery which bears his name, he had many other claims to fame. He was one of the founders of the theory of conservation of force, which subject was treated in a lecture delivered in 1842, and subsequently in an essay on "The Correlation of Physical Force," written the following year. He was knighted in 1872 and was a fellow of the Royal Society and a member of a number of foreign scientific bodies. From 1872 to 1887 he was on the bench, being Judge of the High Court of Justice for twelve years.

The Electrician and the Wattmeter.—At the recent meeting of the Canadian Electrical Association, a member related that his firm had shipped a wattmeter for use on a lighting circuit, and shortly after a complaint was received that it would not operate. A copy of the instruction book was forwarded with the suggestion to see if the plugs which held up the armature from the jewels had been taken out. A reply was received, with thanks for the information, stating that they had not been removed. Later it was reported that the meter still failed to operate and a severe complaint made about it; upon investigation, however, it was found, that the local electrician had taken the meter up to the garret of the house and laid it down on its back, notwithstanding the clearly expressed instructions as to the manner of setting up.

Municipal Robbery.—At the recent meeting of the Northwestern Electrical Association, one of the speakers related an instance of the gross injustice now so frequently visited by municipal authorities upon owners of central stations. At Logansport, Ind., a municipal electric lighting plant was put in —agents of manufacturing companies, according to the speaker, being responsible for the measure—and started on the basis of 7½ cents per KW-hour. In the meantime the private plant had spruced up and gave an excellent service at a low price, commercial arcs being furnished at from $4 to $7 per month. The city consequently found it difficult to compete, especially in arc lighting though more or less trouble was also met in incandescent lighting. Finally, the authorities ordered the poles of the competing company to be cut down, which was done and its existence thus ended.

Patent Law.—In a recent paper Mr. Walter S. Logan, a patent attorney, argues that there is no logic in the present requirement of technical novelty, and proposes that the Federal statutes be revised as follows: "Any person who has invented or discovered any useful art, machine, manufacture, or composition of matter, or any useful improvement thereof, not theretofore *generally* known or used, may, upon payment of the fees required by law and other proceedings had, obtain a patent therefor." He also proposes another modification whereby profits of an invention are to be divided where *bona fide*, *independent* inventors, *independently* reach the same useful results, *in ignorance* of one another. There is no question but that such modifications would greatly increase the business of patent attorneys, and the words we have italicized offer prospects of accompanying litigation that should make the proposals most enticing to the legal fraternity in general.

A Deserved Honor.—Mr. Oliver Heaviside has been placed by the British Government on its civil pension list in recognition of his contributions to electrical science. Though his writings are unnecessarily difficult to read on account of an erratic style, and are also marred by poor puns and other eccentricities, Mr. Heaviside is the intellectual succesor of Maxwell. As remarked by an English contemporary, Mr. Heaviside has chosen for his life work the investigation of problems so abstruse, and he has so consistently disdained to turn aside to make money out of even the most practical of his investigations, that his work must needs be unremunerative, and therefore the pension in this case was peculiarly well applied. Although his work has largely been in the domain of theory, the parts relating to telegraphy and telephony have had a direct practical value, and in the near future when the wave theory of electricity will have taken its proper position to the exclusion of all others, the great value of his books will become more evident than at present.

Unlawful Commissions.—An English court recently rendered a decision assessing damages against a firm which had paid commissions to a buyer of another firm. The buyer, it appears, made a confession upon his death bed concerning his practice of accepting commissions, and implicated a firm of Sheffield cutlers. His employers obtained confirmation by means of a letter written under an assumed name, of the readiness of defendants to subsidise its late buyer's successor, and thereupon entered suit and recovered the amount of commissions paid to its former employe. In summing up, the judge, Lord Russell, said:—"These corrupt bargains are malignant cankers. It is a system dishonest to the fair trader, dishonest to the fair employer. If the evil continues to exist as it has existed in the past, the Legislature must take measures to cut out the canker. It is unnecessary to point out how the evils work; they operate to the detriment of the honest trader, who is above such nefarious practices."

The New York Trade School.—In a pamphlet just issued by this institution, the course of instruction is very fully described. Many illustrations are included giving views of the work performed in the various departments of the school, which is justly famous for the remarkable results which it has achieved under the Auchmuty system, which was here originated. Instruction in electrical work is given on Monday, Wednesday and Friday evenings, from 7 to 9.30 o'clock, commencing October 19 and ending April 8. The fees are $16 for the course, and the class is reserved for young men between seventeen and twenty-two years of age. The manual instruction is as follows: 1. Bell work; annunciators; fire alarm; batteries and connecting same. 2. Telephones, both single and metallic circuit. 3. Telegraph work. 4. Electric lighting, including low tension, incandescent and arc lighting; high tension series arc lighting; alternating high and low tension. Calculating sizes of wires. 6. Methods of distribution of wires. 7. Connecting dynamos, motors, converters, and switchboards, and the care of same. 8. Storage batteries. During the course, lectures applicable to these various subjects are given.

Technical Journalism.—In a recent address, Col. H. G. Prout, editor of the *Railroad Gazette*, spoke—perhaps somewhat too optimistically for general application—as follows concerning technical journalism: "The fortune of the editor of the engineering paper is that he is working for a select audience. He is working for an audience that demands of him, first, that he shall tell the truth above all things; an audience which demands a certain discretion and modesty of opinion; an audience which has discovered that wisdom does not fall like a mantle upon him and clothe him the moment he sits down in an editorial chair; and the sooner the editor discovers this the better for his business. The editor of the engineering journal very soon finds that he cannot establish a wisdom trust, and that the first thing expected of him is to speak the truth, and that he is expected not only to be truthful in intent, but to carry it into effect; and these, gentlemen, appear to me the greatest reasons why you are getting a better class of technical literature to-day than you had ten years ago—the great reasons why technical journalism stands on an honored foundation, and the great reasons why we may hope that the engineering press will go on in the years to come to work steadily for the profit and the glory of the engineering profession."

Acetylene Gas as an Enricher.—In a paper on acetylene gas read before the recent Convention of the Canadian Electrical Association, the admission was made that the gas is not suitable as an enricher for water gas. One of the members commented on this assertion as follows: "We all of us know that there is precious little coal gas manufactured. Very nearly all the gas companies are running with water gas. If that is really the case there does not appear to be very much field for this product as an enricher for the ordinary gas of commerce, as we may call it. The gas companies for the sake of using it as an enricher would never exchange their water gas plants and go back to the old methods of producing coal gas at a vastly greater expense in order to use acetylene gas, though manufactured at a tremendously low rate. My remarks are with reference to gas plants all over the country. We are all aware that the largest gas plants are water gas plants." In reply to a criticism on the absurdity of estimating the cost of a 24-hour electrical horse power at $5 per year, the author made the statement that "about 200,000 HP are available in the Province of Quebec at that price. The reply to a question as to the location of that power was, "In the backwoods somewhere!"

Compressed Air Traction.—Mr. R. A. Parke in *Compressed Air* protests against the "wholly incorrect and misleading statements" which have been made by those who desire to befriend the use of compressed air, and asserts that the efficiency of the electric trolley system cannot reasonably be expected to be materially surpassed by that of a compressed air storage system operating under the most favorable conditions; and that it is certain it cannot be nearly approached by a compressed air system which stores air at such high pressures as have been recently proposed. Calculations are made which, Mr. Parke states, render it evident that a compressed air system which might compare very favorably in point of efficiency with the electric trolley system when operating under a storage pressure of 500 lbs., would be hopelessly out of competition in this direction if operated with a storage pressure of 2000 lbs. Taking sixty-five per cent, as the efficiency between the steam engine and car axle for compressed air at 500 lbs. pressure, he shows that this is reduced with 2000 lbs. pressure to thirty-seven per cent. or to forty-three per cent. under the most economical conditions. Coming from a compressed air engineer and appearing in the organ of the compressed air industry, these facts form a a significant commentary on the inflated claims of those exploiting the compressed air traction systems now on the stock market.

Iron Loss of Transformers.—In a recent lecture Prof. J. A. Fleming said that in Great Britain there are at present about fifty alternating current central stations, supplying not less than 1,100,000 8-CP lamps. This amount of lighting requires the expenditure of 54,000 HP, or 40,800 KW at full load, and hence the transformer capacity is at the very least equal to 40,000 KW. These transformers all contain an iron core, which has to be magnetized and demagnetized 200 times a second, or 6,000,000 times a year. The total weight of iron cores in the whole of the transformers will be certainly not less than 400 tons, and it will require at least 400 KW to maintain the magnetization of these cores. If these transformers are connected with the circuits only, on the average 4000 hours a year it is very easy to see that the magnetisation of the cores of the transformer will require not less than 1,600,000 KW hours spent per annum in magnetism, and this means at least 16,000,000 lbs. of coal, or 8000 tons. Hence, in the United Kingdom there are at least 400 tons of iron forming the cores of transformers, and these involve at least an expenditure of 8000 tons of coal, costing some $30,000 to maintain that magnetization. It is, therefore, Professor Fleming adds, easily seen that the study of the construction of the alternate current transformer, and its possible improvement, is one which is not at all unimportant from an engineering point of view.

Statistics of Electric Traction.—The following electric railway statistics for the United States, compiled by the *Street Railway Journal*, indicate an industrial development rarely, if ever, equalled, representing, as they do, a growth of practically less than seven years. For purposes of comparison, statistics of horse and cable street railways are added:

	Miles.	Cars.
Electric Railways…………	12,133	34,971*
Horse " ……………	11,219	5,385
Cable " ……………	5,099	4,871†

* 26,242 motor cars, 8,729 trailers.
† 3,329 grip cars, 1,542 trailers.

The following table gives the distribution in the United States of the mileage and cars of electric railways:

	Miles.	Cars.	
		Motor.	Trailers.
New England………	1,729	4,808	760
Eastern States……	3,884	10,382	1,373
Central States……	4,105	7,881	5,577
Southern States….	1,793	1,295	275
Western States……	1,622	1,876	744

It will be noted that the proportion of trailers to motor cars varies considerably in the several divisions of territory, the percentages being, in the order above given, 16 per cent., 13 per cent., 71 per cent., 20 per cent. and 40 per cent., respectively. The funded debt of the street railways of the United States is $590,596,391, or $40,800 per mile of track, and the total capital liabilities are $1,375,410,162, or $95,000 per mile of track.

Cheap Water Powers.—In *Power and Transmission* for July, Col. Samuel Webber gives some interesting figures as to the cost of several well-known water powers. At Augusta, Ga., the John P. King mill pays the city $6.88 per yearly HP for 1,468 net HP of water; the cost of the wheel pits, tail and head races was $25,000, and of the turbines and shaftings the same sum, making an annual charge per HP of $3.42 on the basis or ten per cent. for interest and depreciation. Adding seventy-five cents for attendance and oil; the total cost at the turbine shaft is $11.05 per yearly HP. At Columbia, S. C., $7.00 per yearly HP is charged for water in quantities of less than 500 HP and $5.00 for larger quantities. In one instance where 2,000 HP are used, the cost of pit and races was $55,000, and of wheels $20,000, making a total expenditure of $37.50 per HP. The annual charges are $3.75 for interest and depreciation, $5.00 for water and $1.00 for expense and attendance, making $9.75 annually, not including charge on electrical plant. At Carritunk Falls, Me., on the Kennebec River, there is a natural rock gorge at the dam site, which made the cost of permanent construction very low. The volume of water is considered reliable for 5000 HP all the year, though but 3000 are now utilized. In this case the outlay for dam, flume, head gates, wheel pits, etc., was about $15.00 per HP on a basis of 3500 HP, and the cost of wheels for 3000 HP was about $9.00 per HP, or $24.00 in all. Taking depreciation and repairs at two per cent. each, taxes and insurance at one-half per cent. each, supervision at one per cent. and interest at five per cent., the annual fixed charges are eleven per cent., or $2.64 in all. Adding sixty cents for race and seventy-five cents for attendance the total becomes $3.99 per yearly HP. Mr. Webber, in conclusion, says that taking the investment at Carritunk Falls as a minimum at $24.00, the cost in any ordinary case will not be likely to exceed that at Concord or $78.88 for the minimum flow, and that an average of $50.00 per HP may be considered as a fairly safe estimate under ordinary conditions for dam, canal, wheel pits and wheels.

Sunshine and "Moonshine."—A Dr. Adam Miller recently delivered a lecture before the Chicago Academy of Science which is characteristic of a vast amount of twaddle inflicted on the public under the guise of scientific theory. After making the dogmatic assertion that "Electromagnetism plays an important part in Nature's strange phenomena," the Doctor enounced the following startling theory:—"If gravitation alone acted on celestial bodies, without the counteracting and controlling influence of electromagnetic repulsion, suns and their satellites would be drawn into a solid mass, and wreck and ruin would be the result. This is a truth that has scientific demonstration." The "scientific demonstration," unfortunately, was not given, though it should largely exceed in importance and interest the lunar "demonstration" by which Newton established the gravitational theory which the Doctor, in such few words, so thoroughly disposes of. We are also informed—unfortunately again without "scientific demonstration"—that "electricity performs an important part in producing the light of the sun and in conducting its rays of light through interstellar space to the different planets and their satellites. It is the thing out of which sunshine is made. By its action on the sun's rays they are changed into light and heat, by which all forms of life are made possible on earth." The Doctor also alludes to some experiments he has made—which, however, he neglects to describe—which "naturally lead to the conclusion that revolving planets in their rapid movements through space may be centers of power to evolve electromagnetism to an almost unlimited extent. If the planets are the offspring of the sun we may naturally conclude that they contribute their part in supplying the grand old luminary with materials out of which sunshine is made." The "natural conclusion" of the Doctor is a favorite with his class of "scientists", and seems to differ from the syllogistic conclusion in that it is untrammeled by premises and above the servitude of facts. With a Michelson and others within call, would it not be well for the Chicago Academy of Science to submit papers before acceptance to competent authority for judgment?

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Rontgen Ray Apparatus.

The articles in this issue by Drs. Houston and Kennelly, and Prof. McKissick, on Röntgen ray apparatus furnish precise indications as to the parts and arrangements of such an apparatus for commercial and medical purposes, as well as giving directions for making such parts as cannot be readily secured in the market. The practical information here given is, we believe, the first of its kind published, and should prove particularly useful in advancing the use of the Röntgen ray in hospital work, since by its means any skillful electrician can there make the necessary installation.

Inverted Arc Lamps.

The use of inverted arc lamps does not appear to take hold in this country as in Europe, notwithstanding the satisfactory results attained in the several cases where inverted arcs have here been used. The advantages for large interiors are certainly manifest, as an illumination may thereby be obtained approaching nearly that of daylight and, above all, without the eyes being exposed to the glare of numerous centers of light, which, besides, by contracting the iris, causes an actual waste in lighting. Of course, some height of ceiling is required in order to obtain the best effect from an inverted arc, and as there are little data on this subject, it would pay the large user of incandescent lights to try the experiment with an arc lamp rather than wait for definite information on the subject. Even if a failure, something will be gained from the more attractive appearance of the room in which the experiment has been tried, from its walls and ceilings having been previously whitewashed or painted.

High-Voltage Incandescent Lamps.

The information gathered from various sources and printed in another column, concerning the practical working of high-voltage incandescent lighting will be found of much interest. As will be seen, the experience with 220-volt lamps has been uniformly favorable, and in view of this testimony and the similarly favorable experience in England, an account of which appeared in our July issue, there can remain little doubt but that high-voltage incandescent lighting has before it a wide field of usefulness, particularly in smaller towns and for large isolated installations. The lower rated efficiency of the high-voltage lamp is somewhat of a disadvantage, but this to some extent is compensated for, it would appear, by a lengthy life and little drop in candle power. The difference of efficiency between low and high-voltage lamps, after all, is not so great as might be thought in view of the present talk about 2½-watt standard voltage lamps. If the comparison were made with 3½-watt standard voltage lamps, it would more nearly be in accordance with actual practice at present and perhaps for a long time to come.

Lighting Towns and Small Cities.

Little judgment is usually displayed in selecting street systems of electric lighting for villages, towns and smaller cities. Arc lighting is almost invariably adopted, in some cases doubtless not from choice, but through fear that a less glaring system of illumination might be considered to indicate a spirit too retiring on the part of the community employing it. Yet for villages and towns and for residence streets of smaller cities, arc lighting is not only out of keeping with the surroundings, but less efficient than incandescent lighting both economically and optically, and where there is much foliage these disadvantages are intensified. An exception should be made with respect to the business streets of more important towns, while even in smaller places a few arc lights can be usefully applied, at least during certain hours.

For towns and smaller cities the ideal system of illumination is by the incandescent series system for residence streets and outlying districts, with arc lights for the main business streets, which latter lights may be employed only during business hours, circuits of incandescent lamps replacing them after the stores have been closed. As to the relative cost of arc and series incandescent lighting, let us assume that a 1200-CP arc costs $80 per year and that the annual cost of a 24-CP incandescent lamp is $14 per year. The average horizontal intensity of a 1200-CP arc will not average over 300-CP, which is equivalent to a cost of $6.40 for each 24-CP of light; but the average efficient illumination over the territory served will be less than with the rated candle power equivalent in incandescent lamps on account of the better distribution of the light from the latter. This comparison takes into consideration the waste of light in the immediate vicinity of an arc through its too great intensity, but does not consider the blinding effect on the human eye when subjected to such great variations of illumination as are incident to arc lighting when the lamps are widely spaced. In a future issue we hope to print some curves illustrating the relative cost of efficient illumination by the two systems.

Another Patent Decision.

The vagaries of patent litigation were again illustrated in a recent decision of a Federal Circuit Court of Appeals, bearing on the sale of trolley stands by others than the owners of the broad trolley patent. In March of this year when the case came before the Circuit Court whose decision has just been so modified as to practically amount to a reversal, that Court held that the defendants could not lawfully sell trolley stands, though such stands were not covered in detail by the fundamental trolley patent of the complainant, and though they were merely sold to be used by purchasers to repair or replace parts of original equipments sold by the complainant. The reasons given by the Court for this view were, that the supply of the parts in question in reality intentionally aids other parties in the unlawful making, selling or using of the patented system as a whole; and that the replacement of a lawful by an unlawful trolley base or stand is not a legitimate repair, but a reconstruction of the combination patented. All parties, the opinion stated, were infringers who contributed toward the infringement of the entire combination by supplying necessary and durable parts thereof.

On July 29 the higher court before which the above case came on appeal took what appears to be a diametrically opposite view of the legal points involved. The opinion quotes with approval a precedent stating that "if a person legally acquires a title to that which is a subject of letters patent, he may continue to use it until it is worn out, or he may repair it or improve upon it, as he pleases, in the same manner as if dealing with property of any other kind." The opinion also holds that the trolley stand is not the vital part of Van Depoele's invention, though a portion of it is an element of the combination; and that while it is not intended that a trolley stand should be broken, or should lose its useful capacity, either calamity may befall it, and the right to replace the injured part by a new stand from any one who can supply the article, should be conceded by the owners of the patent. Moreover, if, the day after his purchase from the owner of the patent, a purchaser chooses to substitute a stand which is better made and better adapted to his peculiar needs, he has a right to do so.

One of the judges filed a separate opinion taking still stronger grounds than those just quoted. It states that trolley stands can be as legally sold as the rails, the poles, the wires, the screws, the paint or any other article which may be required for use by those who own and operate electric railways in which improvements covered by the patents of the complainant are used. An electric railway company can repair its trolley stands, substitute new ones for those old or worn out, or substitute a better or improved kind for those originally bought of the complainant, and any one has an equal right to make and sell the stands to such railways for that purpose. As to contributory infringement, the defendant being entitled to sell trolley stands, he is under no obligation before selling them to inquire whether the purchaser intends to make an illegal use of the stands.

The arguments used with respect to the trolley stand apply, of course, with still greater force to the trolley pole and wheel, so that the effect of the decision is to enable street railways to purchase all trolley repair or substitution parts from whomever has them for sale, thus reducing the monopoly of the patentee to the profit on the original trolley equipment. If the principle here laid down is accepted by the courts in general, the value of many other patents will be notably decreased.

Zinc in Boilers.

When surface condensers were first generally adopted for marine use, the gravest trouble was experienced from pitting in boilers. A British Royal Commission appointed to investigate the cause of the pitting, made one of the most exhaustive studies ever given to a subject of the kind, and in its report advised the employment of zinc in boilers to counteract galvanic action, and recommended that petroleum cylinder lubricants should alone be used, vegetable and animal oils being strongly condemned on account of the corrosive fatty acids formed under conditions similar to those existing in boilers. The two recommendations were at once adopted in marine practice, and trouble from boiler pitting almost entirely ceased. Unfortunately, two remedies being applied at once, their effects could not be differentiated, and though no difference of opinion now exists as to the necessity for the use of mineral cylinder lubricants, the zinc question has remained an open one for a quarter of a century.

For some years marine engineering opinion has inclined against the utility of zinc in boilers, and there appears to be very good grounds for this view. The argument originally advanced in favor of the use of zinc was, that its presence made a galvanic cell of the boiler, and being electro-positive to iron, electrical action was concentrated on the zinc, the iron being thus protected. As, however, the electro-negative particles carried into the boiler from the material of the condenser were supposed to be deposited in small pellets where the pitting occurred, the action on this assumption was a local one, such as occurs in impure battery zincs, and this explanation fails. An additional theory, however, was advanced, according to which the entire surface of the iron of the boiler becomes, merely through the zinc contact, passive to electrolytic corrosive influences. One of the reasons offered in support of this theory was that the iron pot of a certain type of voltaic cell is not attacked by the acid contained on account of being thus rendered passive, but subsequently it was shown that this was due to an iron oxide formed on the surface, which protected the metal. Apparently through a confusion of ideas, zinc also came to be considered as a scale preventive. Among the *a posteriori* arguments advanced in favor of this use was one asserting that electrical action deposits a thin layer of hydrogen on the iron, which prevents the adhesion of scale; and another based upon an assumed action of the electric currents generated and passing through the water, in keeping apart the scale-forming molecules and thus causing them to be deposited merely as a powder.

Whether any or all of the above theories are well founded happens to be a matter of indifference, for in practice the essential condition upon which they are based does not obtain. In order to have any electrical action whatever there must be metallic contact between the iron and zinc, and no such lasting contact can be maintained in a boiler, at least with the methods in vogue for securing the zinc. The contact surfaces may be ever so carefully cleaned, and the greatest of care taken to secure metallic contact when the zincs are originally suspended, yet in a very short time the zinc will be electrically insulated from the boiler by deposits between the contact surfaces. If, however, some method were devised to insure continuous electrical contact, the case would not be improved, owing to the very rapid consumption of the zinc that would ensue on account of the low resistance of the electrical circuit. Owing to the great area of iron surface opposed to the zinc, and the impurities (particularly if saline) in the water, the internal resistance of the iron-zinc voltaic cell would undoubtedly be small, thus producing a large current, which would rapidly consume the zinc or, in some cases, result in a layer of an insoluble zinc salt quickly forming on the surface that would serve to protect it from further electrical action.

It has been noticed that in a few hours after placing zinc in a boiler using sea water, and in which steam had been raised in the meantime, the surface of slabs assumed a condition not different from what is usually noticed after months of immersion, thus pointing to a strong action when the contact and surface were clean—the final crumbling away of the material probably being due to chemical rather than to electrical action. The result of the use for many years of zinc in the boilers of naval vessels has been negative; in some cases where tests were made by suspending zincs in only part of the boilers of a vessel, no difference in scale formation or pitting was noted between the boilers containing zinc and those from which it was absent. As the arguments in favor of the use of zinc in boilers are little more than speculative, and since, besides, the conditions upon which they are based do not obtain in practice; in the lack therefore, of positive evidence of beneficial effects from the use of zinc, it would seem that an engineer is reasonably safe in assuming that he can neglect applying this so-called remedy for the evils to which a steam boiler is heir.

CONSTRUCTION OF A TESLA-THOMSON HIGH FREQUENCY COIL.

BY PROF. A. F. MCKISSICK.

The following is a description of the construction of a Tesla-Thomson high frequency coil, large enough to give a five-inch spark and excite Röntgen ray tubes.

To excite the Tesla-Thomson coil, a high potential transformer of from 10,000 to 15,000 is necessary. The construction of this transformer will be first given. Fig. 1 gives a partial cross-section of the transformer, which is made as follows: A two-inch iron pipe, sixteen inches long is slotted the whole length, either in a milling machine, planer or shaper. This slot need not be more than $\frac{1}{16}$ in. in width. The pipe is then insulated with ordinary wrapping paper to an outside diameter of 2⅛ ins., shellac being freely used, and is then wound with No. 13 B. & S. double cotton-covered wire for its whole length (one layer). It is then covered with paper and shellaced until the outside diameter is 2⅝ ins.

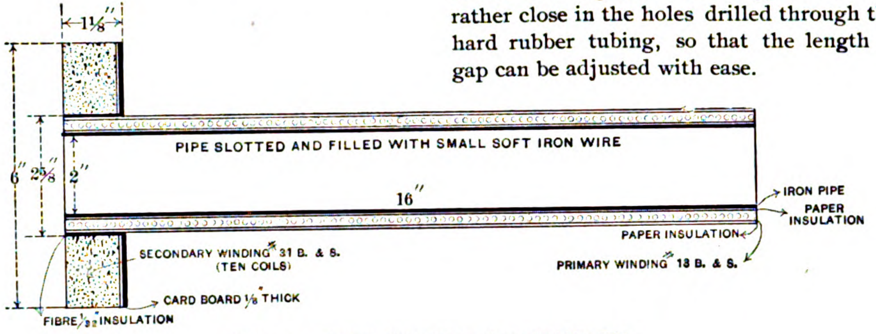

1⅛″
6″
2⅝
2″
PIPE SLOTTED AND FILLED WITH SMALL SOFT IRON WIRE
16″
IRON PIPE
PAPER INSULATION
PAPER INSULATION
SECONDARY WINDING #31 B. & S. (TEN COILS)
PRIMARY WINDING #13 B. & S.
CARD BOARD ⅛ THICK
FIBRE 1/32 INSULATION

FIG. 1.—HIGH TENSION TRANSFORMER.

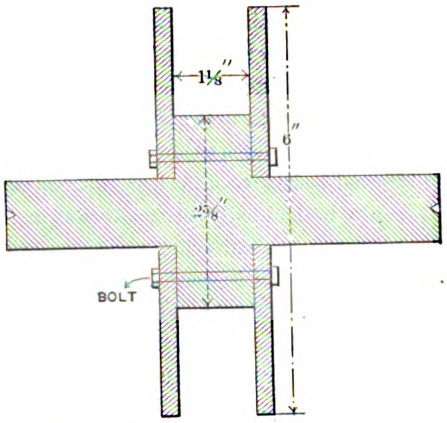


FIG. 2.—FORM FOR WINDING COILS.

The next step is to fill the pipe with soft iron wires, No. 16 B. & S., each wire being cut eighteen inches long. This completes the primary winding of the high tension transformer.

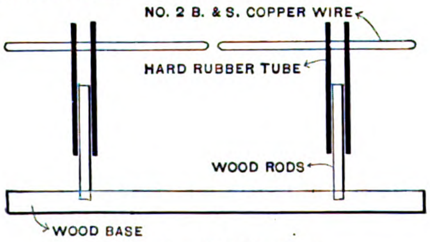


FIG. 3.—SPARK GAP.

The secondary winding of this transformer consists of ten coils wound in a form and thoroughly taped and insulated. This form is shown in Fig. 2, and can be easily made of wood. The wire is wound in this form, shellaced, removed, taped and baked. These coils are then slipped over the primary winding, between each coil being placed a disk of cardboard ⅛ in. thick, care being taken to connect the coils so that none will be in opposition.

The spark gap (see Fig. 3) is made as shown in diagram. The copper wires fit rather close in the holes drilled through the hard rubber tubing, so that the length of gap can be adjusted with ease.

The condenser is made of ordinary 10 in. × 12 in. window glass. A sheet of tin foil 8 ins. × 10 ins. is pasted on one side of the glass with shellac, leaving a margin of one inch. (See Fig. 4.) A strip of tin foil two inches wide is placed across one corner, this strip being placed alternately on each side. For each side of this condenser there should be fifteen plates.

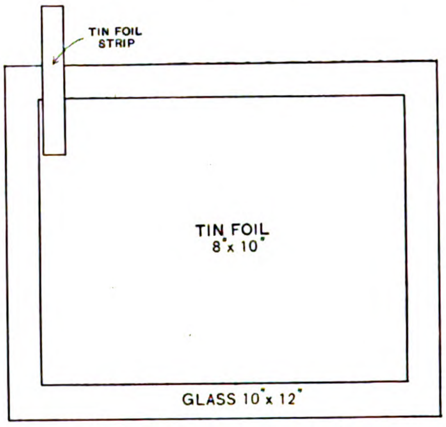


FIG. 4.—CONDENSER PLATE.

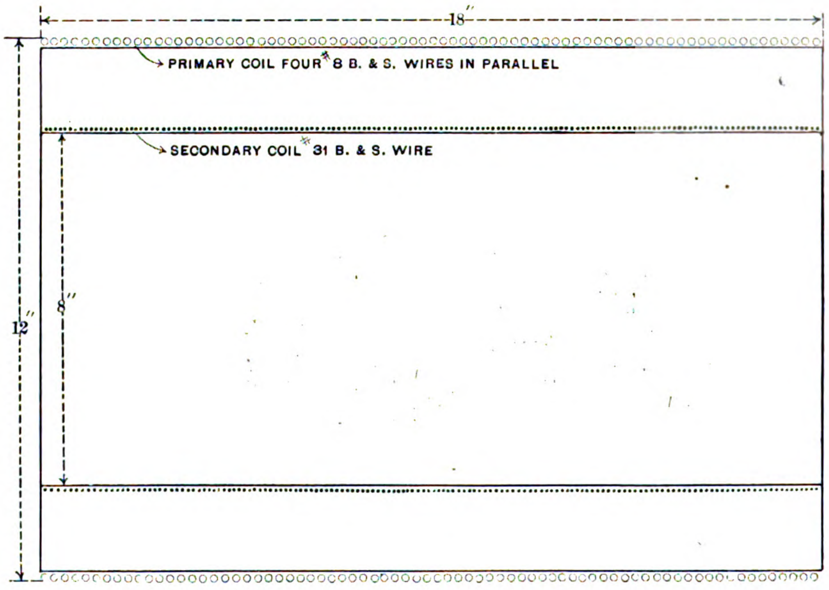

18″
PRIMARY COIL FOUR #8 B. & S. WIRES IN PARALLEL
SECONDARY COIL #31 B. & S. WIRE
8″
12″

FIG. 5.—PRIMARY AND SECONDARY COILS OF HIGH FREQUENCY TRANSFORMER.

To build this condenser proceed as follows: Place on a smooth surface a condenser plate with the connecting strip projecting on the right. On top of this plate place another piece of glass, 10 ins × 12 ins., that has no tin foil on it at all. Then place a condenser plate with the strip projecting on the left. Then a piece of glass without tin foil, and on top of this a condenser plate with the strip projecting on the right, and so on. This construction gives two thicknesses of glass between each sheet of tin foil, which is absolutely necessary.

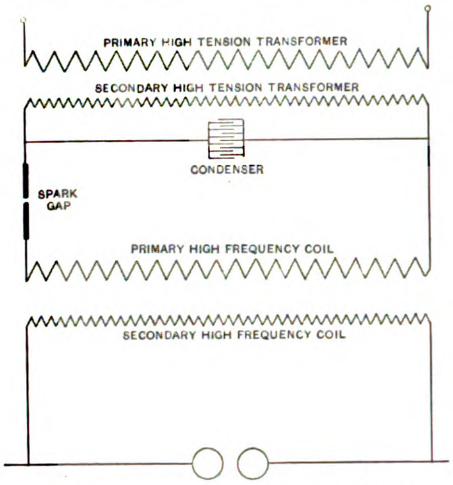

PRIMARY HIGH TENSION TRANSFORMER
SECONDARY HIGH TENSION TRANSFORMER
CONDENSER
SPARK GAP
PRIMARY HIGH FREQUENCY COIL
SECONDARY HIGH FREQUENCY COIL

FIG. 6.—DIAGRAM OF CONNECTIONS.

The high frequency coil is made as follows: Wind an eight-inch paper cylinder eighteen inches long with No. 31 B. & S. double cotton-covered wire (or larger), leaving a margin at each end of about one inch. This is the secondary winding. The primary winding is placed on a twelve-inch paper cylinder eighteen inches long and consists of fourteen turns of four No. 8 B. & S. double cotton-covered wires in parallel. Each of these No. 8 wires is wound on separately, then the four ends at the beginning and ending are soldered together. Between wires of different polarity, as an extra precaution, two turns of cord are wound. The primary and secondary coils are then shellaced and baked. After being baked, the secondary coil is placed concentrically (see Fig. 5) inside the primary and the connections as shown in Fig. 6 then made.

The primary of the high tension transformer must be excited with an alternating current. With a frequency of 60 cycles per second 50 volts will suffice, and for 125 cycles per second 100 volts. The length of the spark from the secondary of the high frequency coil will depend on the width of the "spark gap," consequently, in exciting a tube it is best to start with the "spark gap" very short, then gradually increase until the tube is properly excited. When the terminals of the secondary high frequency coil are separated farther than five inches, a spark will pass from the secondary to the primary of the high frequency coil. By the use of a good insulating oil a much longer spark can be obtained from the high frequency coil, but for exciting Röntgen ray tubes a five-inch spark will be sufficient.

INTERIOR WIRING.

SWITCH CONTROL.

Switch control has been considered by many to be a problem that solves itself. This may be the case when the general excellence of the result is unimportant, but when other conditions prevail every hint is welcome.

The position of the switch is an important point, but an electrician or engineer is not necessarily the best judge of this. An architect is frequently even more competent, and the owner of the building to be wired, while not conversant with current practice, usually has sound ideas on such matters when various common methods are submitted to him.

As a general thing, in small rooms the place for the controlling switch, if there is one, is near the door on the knob side. The first thing desired when entering a dark room is light, and with the switch thus conveniently at hand it can at once be had without advancing further. Similarly, on leaving the room the last thing is to extinguish the light, and it is never convenient to do this by a switch near some desk in the rear of the room, and then meander to the door in the dark. It would seem that this location for a switch is so obvious as not to need pointing out, but judging from a number of personal experiences searching for a switch in hotel rooms, this is not the case. In one large hotel in New York City, it is necessary to have the electrician show the location of switches to new guests, as they may be behind an inner door in a closet, behind the head board of a bed, etc.—the switches apparently having been placed with reference to easy wire runs rather than with any thought of convenience in use.

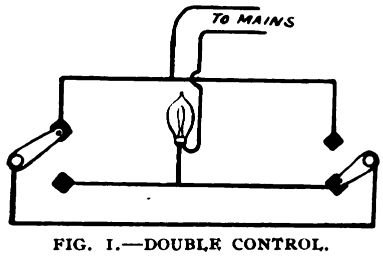


FIG. I.—DOUBLE CONTROL.

There are, however, many special cases where this rule by no means applies. In lighting a cellar it is convenient to have the switch at the head of the stairs in the room above. The same is true of hallways. In halls and theatres the switches are usually banked in a cabinet near the stage in a little room adjacent thereto. In all such cases when the operator cannot see the lights he is manipulating, the switch should show by its position whether it is on or off. In a sleeping room, while it is convenient to have a switch near the door in the ordinary way, it is often required that a switch be placed within easy reach of the bed, so that the room can be lighted without arising.

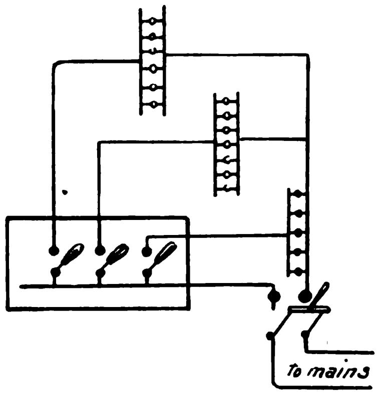


FIG. 2.—LIMITED CONTROL.

Fig. 1 shows an arrangement of connections whereby the lights can be controlled at will from either of two positions irrespective of the other switch. This is also an excellent device for halls and gangways, where it is desirable to light the hall on entering and to extinguish it at another point after passing through.

Two single-pole, double-throw switches are used. The connections are as shown in the sketch. By tracing the connections, it will be seen at once that the lamp is lighted and extinguished by throwing either switch, as they are in series with each other. If, however, one switch be thrown so that the lamp is out, the latter may be relighted by throwing the other switch to the side that formerly extinguished the lamp. In short, the lamp may be controlled from either station entirely independently of the other. Two-point snap switches are now made for just such cases as these.

Another arrangement that is occasionally useful is shown in Fig. 2, and intended to limit the control of a main switch. For example, suppose the case of a gymnasium or hall in an establishment such as a boarding school. In such a case it may be desirable to limit the number of lights that can be turned on in the room by the occupants. To do this a single large switch is placed in the room, and is conveniently at hand for those who desire to use it. From this switch, which should ordinarily be a double-pole switch to comply with insurance rules, circuits branch, in each of which is a single-pole switch located in a cabinet under the control of the manager of the building. It will at once be seen that he has complete control of any or all of the circuits, as long as the main switch is thrown. Thus, if the case is that of a gymnasium, which is to be closed at a certain hour, he can at that time extinguish the lights in the gymnasium and leave those in the bath rooms and lockers burning. As the last man leaves the room, he throws the main switch, thus leaving the entire room dark. In due course, the switch controlling the bath and locker room lights may be thrown, and thus render general extinction certain in case the last man to leave has been negligent. In other cases also this device may be useful.

In some cases it may be convenient to reverse the arrangement; that is, to have the main switch under the control of the janitor, so that when he leaves the building for the night, he can so so in full confidence that all lights are out, without making a tour of the premises. In any building receiving light from a local lighting company, a large jack knife switch should be put in back of the meter, to be opened in case the building is locked up for the summer or similarly left to itself for a period of time. In such a case a plug switch, of which there are several types on the market, is convenient. With such a switch the plug can be removed and locked up, thus effectively preventing the closing of the switch by unauthorized persons.

The theatre is, perhaps, the place where the greatest ingenuity in switch control can be utilized, as so many different effects are desirable—the more the better. In such a place it is necessary to control the brilliancy of the lights. In the flies, side and footlights their brilliancy must be completely under control, for any grade of illumination is likely to be needed. In the main house, however, it is not necessary to have such complete control of the brilliancy of the lamps, and if this control were done by the ordinary method of resistance in series, it would be extremely wasteful of power where so many lights are in circuit. This is an important factor where the consumer uses a meter.

The main body of the theatre should be wired on the principle shown in Fig. 3. This will render resistance unnecessary. It will, it is true, give but two gradations of brilliancy, but it will avoid both the first cost and subsequent waste of regulating resistances. It is sufficient for the cheap theatres and concert halls, and is not out of place in the main auditorium of more elaborate establishments. It will be seen that the device simply connects the lamps in series or multiple across the mains, by the throw of a double-throw, three-pole switch.

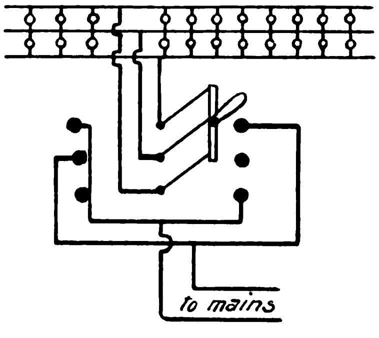


FIG. 3.—THEATRE CONTROL.

If the contractor has facilities, he can make the special switch shown in Fig. 4, and thereby offer his customers a control having three steps, namely: All the lamps at full voltage—half the lamps at full voltage—all the lamps at half voltage. Such switches controlling the circuits in a theatre auditorium would give a gradation that should satisfy the most fastidious proprietor. It will be noted that there are really four steps to the switch; that is, either half of the lamps are available. Remembering that when the performance has begun, the lights in the lobbies and ante-rooms are unimportant, it may easily be seen that these lights may be worked in as a part of one of the halves of the theatre circuits. By this simple means the halves, though equal in number, will be unequal in the auditorium of the theatre, and thus four instead of three grades of light are obtained therein.

If it is not desirable to have the lights in the lobbies vary up and down in this manner, the extra portion of the half giving the least grade of illumination at full candle power, may be formed into an electric sign on the front of the building. The fluctuation of the lighting of this sign will serve to attract attention to it from the street, and means may be provided for lighting it independently. In any of the combinations, the theater manager is getting some good out of all his current, and none is wasted in heating resistance. Moreover, such switches as those described can be made at much less cost than a controlling rheostat.

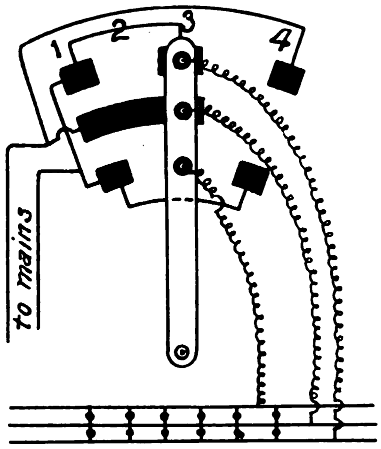


FIG. 4.—TRIPLE-CONTROL SWITCH.

It is to be understood that the switch shown in Fig. 4, is merely diagrammatic, and that it needs to be suitably designed mechanically. It may be added that the three studs on the switch arm are not electrically connected, but merely make contact with the plates beneath them, as the switch arm swings over. Such a switch could readily be designed on the principles of a street car controller.

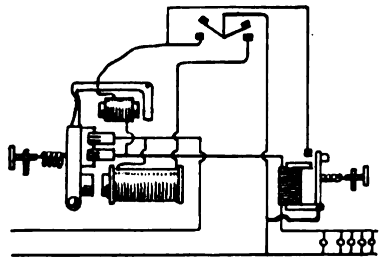


FIG. 5.—RELAY SWITCH.

The brilliancy of sign lamps can be raised in the same way. In a large electric sign with two circuits thus controlled, the manipulation of the switches will at once attract attention. The circuits should be so arranged that their lamps alternate with each other on the sign.

There are several types of switches now on the market known as relay switches. The actual switches themselves are operated by magnets, the circuits of which are controlled by buttons. Pressing one push button energizes a magnet and tightly closes a switch, and a little latch keeps it from flying open. A second button operates a magnet which trips this catch and opens the circuit. By a very simple device this switch is also made to act as a circuit breaker. A coil of wire in series with the circuit to be protected is adapted to raise an armature and close the trip magnet circuit whenever the current becomes excessive.

This circuit breaker once installed needs no attention. It resets itself and will not stay closed till the trouble is removed. Another feature of the switch lies in the fact that the duty of the trip magnet is very light, and it will, therefore respond with great accuracy to the current for which it is set. There is no reason why this switch should not find favor. Fig. 5 is a diagrammatic view of the connections of a single-pole switch of this type. The next section will discuss switch control as applied to electric signs and decorative lighting.

◆

FAULTS IN DYNAMOS.

ARMATURE CONNECTIONS.

In this section will be discussed mistakes in armature connections. These, of course, are made at the factory, or more frequently at the repair shop, where the armature may be unfamiliar. At the factory errors are so seldom made and the subsequent test is so searching, that it will hardly pay to test out an armature before assembling except to make a ground test; but when a local repair shop has rewound or repaired the armature, it is safer to know of its condition before putting it at work in the machine.

Mistakes are almost invariably at the commutator connections. Especially is this the case with drum armatures, for their winding is more confusing than that of the simple Gramme ring.

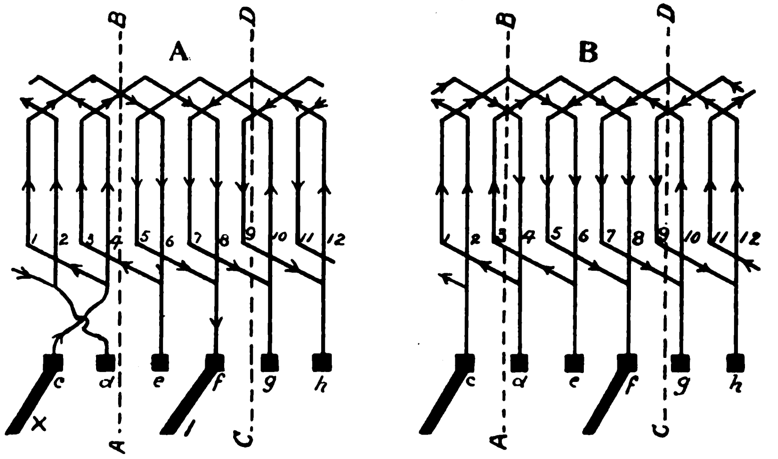


FIG. 1.—FAULTS IN DRUM ARMATURE CONNECTION.

One of the most common errors occurs with a winding arranged like that of Fig. 1. A single wire emerges from the winding and passes down, connecting to a segment of the commutator. Where the windings and connections are bunched under a canvas head, less care is paid to symmetry, and where there are a large number of segments and connections, it is very easy to cross a pair of them as at *A* (Fig. 1), the correct connection being shown at *B*.

Now in a correctly connected winding, a current passing through it will traverse one-half of the wires in one direction and the other half in the other direction, as shown at *B*. Moreover, these halves must be bunched together; that is, all of the *up* conductors and all of the *down* conductors must be together. If an up conductor, such as 10 (*A* Fig. 1), is situated between two down conductors, something in the connections is wrong. In a four-pole machine, the conductors should be divided into four bands and so on.

Such a mistake will cause intermittent sparking when the machine is in operation. That is, there will be sparks at the brushes, which will keep step with the revolutions of the armature. The bars at or near the improperly connected bar, according to the type of winding, are usually eaten away by this sparking, and thus easily located. Unfortunately, there are a number of other causes that produce intermittent sparking, and this effect cannot be taken as positive evidence of incorrect connection, although it may be grounds for strong suspicion.

To definitely establish the fact that an armature is improperly connected, the following method is convenient and sufficient. Prepare a frame of hard wood that can be tightly driven on to the shaft of the armature and only be moved thereon with considerable friction. In holes bored at suitable positions, mount the machine brush studs, and adjust the brushes to their normal position on the commutator. Support the armature on horses, so that it can readily be turned relatively to the frame. Pass a strong current through the armature, as strong as it will carry without overheating. Procure a flat, thin glass bottle and fill it with a mixture of glycerine and iron filings. A very small quantity of filings will suffice. If this bottle be held close to the surface of the armature the filings will arrange themselves in accordance with the lines of force surrounding the armature at that position. For convenience we will use the notation of Prof. S. P. Thompson.

In Figs. 2, 3 and 4, the small circles next the bottle represent wires perpendicular to the plane of the paper. Those with a dot in the center indicate that the current is flowing toward the observer, while those with a cross show that the current is flowing away. It is convenient to consider the dot as the approaching point of an arrow, and the cross as the retreating tip. From what has been said there are obviously only so many places on the periphery of the armature, where there are two adjacent wires carrying currents in opposite directions as there are poles on the machine. If more than that number should be discovered, it would be proof positive of improper connections.

Now if the bottle of glycerine and iron filings be held against the armatnre at such a point, the filings will arrange themselves as in Fig. 2. At any other position on the armature they will arrange themselves as in Fig. 4. A moment's experimenting with the bottle of filings will at once discover these positions of opposite current in adjacent wires. It will be seen that these appearances, like that of Fig. 2, occur at *equidistant positions*. There are two of them if there are two poles, four if there are four poles, and so on, as previously indicated. But if among the wires carrying the current up there should be one carrying the current *down*, due to an incorrect connection, the filings when placed opposite such a point will assume a position such as that of Fig. 3. Its unsymmetrical position with respect to the others, its different appearance as indicated by the filings, and its very existence, point conclusively to the error, and clearly indicate the cause.

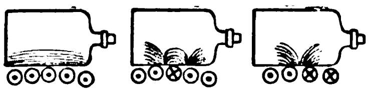


FIG. 4. FIG. 3. FIG. 2.
MAGNETIC DETECTOR.

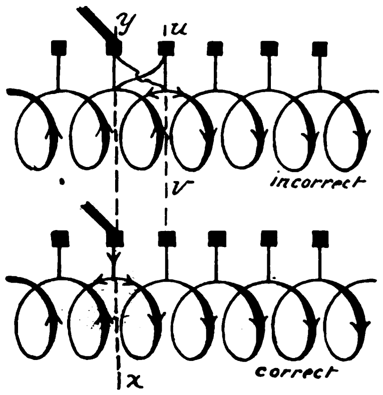
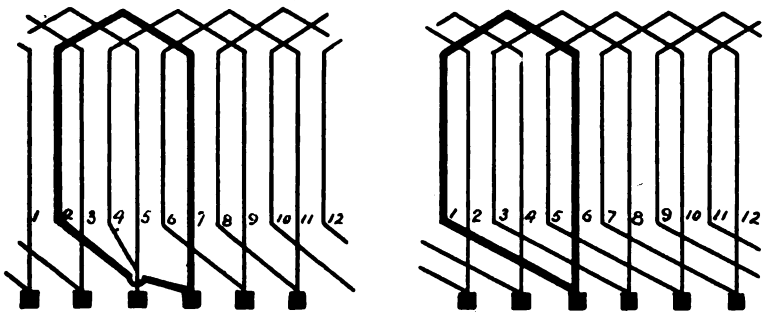


FIG. 5.—FAULT IN RING ARMATURE CONNECTION.

In the case of Fig. 1 it is well to note that *unless the brush is on one of the affected segments*, the incorrect connection will not be thus indicated and the armature will test out correctly. Therefore the armature must be tested with the brushes on each segment in turn till there is no segment that has not been under a brush. If there are two brushes, the armature must be tested half as many times as there are commutator segments. If four brushes one-fourth as many times as there are segments, and so on. The fact that the fault will not be indicated except when the brush is on the affected segment, is a most convenient circumstance, as it not only detects, but locates, the mistake. It is unfortunate that this condition does not obtain in all cases.



FIGS. 6 AND 7.—FAULTS IN ARMATURE CONNECTIONS.

In the case of a ring armature, the winding of which is shown in Fig. 5, such a misconnection would only have the effect of *shifting* the dividing line between the up and down conductors. It would not insert a down conductor among a lot of up ones, or *vice versa*. Therefore, in any position of such an armature arranged as described, there will never be any more points of adjacent reverse current wires than there should be, but when the brush rests on one of the incorrectly connected segments these positions will *not be equally spaced about the armature.*

In such a case the best way is to seek out the proper position of one of these places, and holding the bottle of glycerine there, slowly turn the armature. The instant the brush slips on to the affected segment, there will be a sudden movement of the filings and they will shift along in the bottle.

In fact, this is a good way to test drum armatures also, for the wrongly connected conductor is always so close to the dividing line between the up and the down conductors, that it may be sought for there in almost all windings. Holding the bottle as indicated, at the instant that the brush slips on to the incorrectly connected segment, the second tuft will appear. This is much more convenient than trying the entire armature on so many segments, but unless the manipulator is familiar with the winding, it is never safe to pronounce the armature correctly connected unless this is done. In railway repair shops such methods as this will be found most convenient. Once the facilities are provided the rest is very easy.

Armatures connected with long single wires leading from the windings to the segments are rather less common than those in which two wires come to each segment. Such a winding is shown in Fig. 6 and it will be seen at a glance, that it is merely a modification of Fig. 1.

Fig. 6 shows a common mistake. The commutator connectors of conductors 4 and 2 are interchanged.

In these simple figures the fault sticks out prominently, but in a complicated winding a fault of the same nature is not so obvious. Such an armature placed in a machine would burn out the heavily shaded coil at once, for at a glance it will be seen to be short circuited on itself. But it will also be noted that *it is not in electrical connection with any other part of the armature.* It is therefore, most easily detected. On any *closed coil* winding each segment should ring up with any other, with a magneto bell. Such a misconnected segment will not do so.

Another mistake that is sometimes made is shown in Fig. 7. Mere inspection will not disclose this trouble, for the armature usually *looks* all right unless the connections are minutely traced. Such an armature will refuse to excite, and a magneto bell will discover the fact that *none* of the commutator segments are in electrical connection with each other.

Such faults as these are best detected while winding. The winder should have his magneto at hand, and assure himself that he is right before he goes ahead. Particularly should he do so before he solders in his commutator terminals. It may be added that if such an armature as the last one is rotated in a separately excited field, it will instantly burn out on no load. In fact no current can be drawn from it.

The next section will continue faults in the armature, and will consider some of the open coil machines. The foregoing remarks apply to closed coil types only.

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Repair of Street Railway Apparatus.

EMERGENCY REPAIRS.

This class of repairs is not such a necessity as popularly supposed. On large city lines where there is plenty of rolling stock, and cars run very frequently, it is a waste of time to attempt them, for before they are completed a car is usually at hand to push the disabled car into the barns, where there is another car ready to take its place.

However, this is not always the case. It may be that the car has broken down in the middle of a long interurban way, and must be in some way repaired to proceed at once, or it perhaps happens that a small road is suddenly loaded to its utmost capacity, and every car must be pressed into service. In such cases temporary repairs are a necessity, and therefore a few hints may be useful.

First as to the tools and materials it is advisable to carry. The motorman cannot make bricks without straw, and he must therefore provide himself with a liberal quantity of straw, and a place to keep it. If the management of the road is such that he always has the same car and is responsible for its condition (which is by far the better way), he can get a cheap pine box with a hinged cover and lock, if need be, and place it under the seat. If, however, he changes about from car to car, he can build a little cupboard in the base of the stool that he carries with him. In any case he will find it convenient to carry with him the following tools and materials:

1. Several rolls of black adhesive tape. 2. Slips of mica. (These are most excellent and will insulate cracks and crevices where nothing else will do.). 3. One stick of Chatterton's compound. 4. Ten or fifteen feet of No. 8 B. & S. copper wire, weatherproof. 5. Ten or fifteen feet of one-inch manilla rope. 6. Two or three extra lamps, bunghole type. 7. Plug and socket with fifteen feet of cord. 8. Cutting pliers. 9. Hammer. 10. Screwdriver. 11. Wrench. 12. Small crowbar.

This makes quite a heavy load, and it should really be furnished by the company, and the motorman held accountable. Every one of the articles mentioned will be found useful at one time or another, as the following discussion of probable contingencies will demonstrate.

The equipment may fail in two ways—electrically and mechanically. An ingenious motorman can usually apply suitable temporary repairs to the mechanical difficulties that may occur, but the electrical faults are more troublesome. Especially is this so if the motorman is not thoroughly familiar with every wire and connection on the equipment. This is seldom, if ever, the case, for when a motorman becomes thus expert he can make more money at other vocations. We must, therefore, assume that the method of connection is unknown and go by general symptoms which apply to any system.

Taking the mechanical troubles first, among the most frequent are the failure of the trolley, and also of the motor support. Both of these parts are extremely liable to become broken, but neither of these accidents should stall the car.

In the case of the failure of the motor support, the manilla rope and the crowbar come into play. Block the car wheels as in Fig. 1, and fasten the rope to the stud on the motor which rests on the support. Let the conductor stand inside the car over the trap door and pull on the rope, while the motorman gives the car a little current, running the car in the direction shown by the arrows. He, of course, uses the reverse lever if necessary to accomplish this. The conductor will be surprised at the ease with which he can lift the heavy motor from the ground, and make it fast to the crowbar, which for convenience should be placed across the trap door. The motorman may then proceed to the barn to secure more permanent repairs. It is well, however, to cut the disabled motor out, if it be a front one, and *allow it to operate* if it be a rear one. This, it will be found, is much easier on the temporary support.

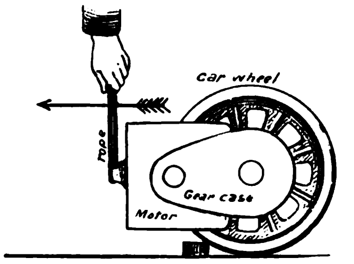

FIG. 1.—FAILURE OF MOTOR SUPPORT.

The failure of the trolley pole often results from its being caught in the overhead construction and wrenched bodily off the car, or it may be that at an inopportune moment, it jumps the wire, and severely collides with the beams of a bridge or some similar construction under which the car is passing. It is sufficient to say that in some such way the accident often occurs. In such a case the car can always be brought home by means of a wire connected to the supply wire at the base of the trolley and held against the trolley wire by hand. Often enough of the trolley pole remains, that it may be utilized, but if such is not the case, a pole may be prepared of a piece of scantling or similar stick as shown in Fig. 2. It is hardly necessary to say that the hand hold, on this improvised trolley, should be well insulated from the wire that it carries.

So long as the man on the roof is careful, there is no danger. True, as his hand shakes, and the contact becomes imperfect there will be flashing arcs at the trolley, but that need cause no apprehension. Although the car thus equipped may appear somewhat sensational as it passes through the streets, it will arrive at its destination, which after all is the object to be attained.

The failure of the brake rigging is a most serious accident. If it be in the chain or any of the tension rods, the rope may replace the injured members until the car barn is reached. Of course, in such a case the motorman must stand ready to use his reverse lever, and must greatly increase the length in which he makes a stop. It is dangerous to attempt a severe grade with such a makeshift, but it is more dangerous to attempt to run home without some such provision. If the rear brake is intact, it would be better to use that, the conductor operating it according to prearranged signals given by the motorman's gong. In case the brake rigging should fail on a steep grade, of course the reverse lever should be used. If the fuse blows or the trolley comes off, throw the controller handle to the last notch. The chances are that the car will stop very abruptly as one of the motors builds up as a dynamo and overpowers its mate, turning it as a motor in the opposite direction. This is terribly hard on the motors and should not be used unless in a positive emergency.

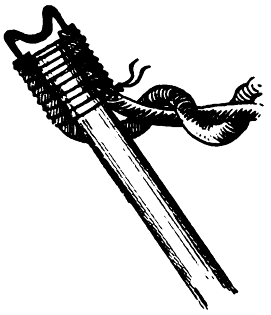

FIG. 2.—EMERGENCY TROLLEY.

Controller troubles are quite frequent. Among them failure to make contact is the most troublesome, especially on the older types. The arcing wears away both fingers and contacts, until the condition obtains that contact is sometimes made and sometimes not, and always with more or less arcing. Presently the car refuses to start. An examination of the controller will usually disclose the contact that is faulty, and the tension of the finger may be increased. If no means are provided for this, or if the limit of tension has been reached, the controlling fingers may be interchanged among each other. A poor finger is sure to be opposite a poor contact plate, and such interchanging will distribute the evil and prevent its being so pronounced at any one place, as to interfere with the operation of the car. On reaching the car barn suitable repairs can be made.

Another trouble that occasionally is encountered is the arcing from ring to ring of the controller. This affects the running of the car in various ways, according to what contacts are thus momentarily connected. It occurs most frequently on turning off the current, and is due chiefly to the discharge of the inductive field magnets.

Vulcabeston and fibre "fences" are usually provided to prevent this, but sometimes holes are burned in these, and they cease to be effective. A few slips of mica cemented over these holes with Chatterton's compound will effectively close them till more permanent repairs can be made.

Should a portion of the equipment be damaged by lightning, it does not follow that the ground lies in the winding. In fact, it is more probable that it is in the wire just entering the motor from the outside circuit. If such injury is suspected, open the trap doors, and give the controller a notch. The grounded place will indicate its location by an arc and smoke. If it is on one of the leading-in wires, a little tape will permanently repair it, and what is usually an insurmountable difficulty to the average motorman is easily eliminated. Modern motors are so well insulated that the grounds occurring are fully as likely to be in the leading-in wires as in the windings. The motorman should not let these places escape him, just because they are the simple ones.

Grounds from lightning are frequently found at the bushings of the rocker studs, for the discharge frequently prefers to puncture here, rather than enter the inductive armature. Such places may easily be repaired with slips of mica.

It sometimes happens that the armature winding breaks. It usually begins by short circuiting a bobbin, which promptly gets so hot that it scorches the insulation and melts the solder connection at the commutator. Centrifugal force throws the joint open, and the commutator begins to flash. On examination, it will be found that one bar is severely burned and between this bar and the next one that comes under the brush as the armature rotates is the faulty coil. This may be avoided for the time by bridging. Little wedges made of copper wire hammered flat, may be driven down between these bars as in Fig. 3. This makes the necessary connection, and the armature will operate without flashing until the coil can be repaired. This is never very good for the commutator, and should not be tried if the other motor is sufficient to get home on, or the next car is not far away.

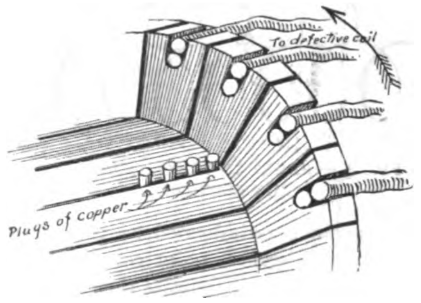

FIG. 3.—CUTTING OUT ARMATURE COIL.

◆

The Power of Horses.—An English engineer has reported the results of some dynamometric experiments on the pull of horses. In one case a powerful draught horse exerted 5.44 HP over 138 ft., and it is concluded that an ordinary street car horse may exert 3¼ HP at the moment of starting a car. A French experiment is quoted where the horses were called upon during one or two minutes to make an effort equivalent to 5.2 HP, but which exertion, it was found, is liable to result in seriously straining a horse.

THE STEAM ENGINE INDICATOR CARD.

In the present article the subject of "ideal" indicator construction will be discussed. Sometimes the "ideal" card is called the "theoretical" card, but this is an abuse of the latter word, since the ideal card is based upon assumptions that are not in conformity with the theory of the working of steam, although such assumptions may prove useful in giving a basis for the exercise of the judgment.

In constructing the ideal card, it is always necessary to have a line of perfect vacuum, whether the exhaust of the engine is above or below the atmospheric pressure. This follows from the fact that the atmospheric line is purely arbitrary as far as expansion is concerned. Steam would expand in a cylinder exactly the same whether the outside pressure were that of our planet, or that of any other heavenly body, or if the cylinder were off in space.

It is customary in constructing cards to assume that steam expands as a perfect gas; that is, when the volume of the gas is doubled the pressure is halved, or—what is the same thing—when the steam is given two expansions, the final pressure becomes half the initial pressure. This is not exactly true, but as many other errors are involved in ideal cards, the assumption is sufficiently close, particularly as very much greater labor would be required in laying down expansion lines that conform more nearly to correct theory.

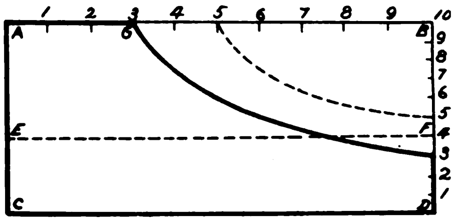

FIG. 1.—IDEAL INDICATOR CARD.

In Fig. 1 suppose $A\,G$ is the admission line of an ideal card, $E\,F$ the atmospheric line and $C\,D$ the line of absolute vacuum. Furthermore, suppose that steam is cut off at three-tenths stroke, or at G; then the final pressure, 3 D, will be only three-tenths the initial pressure or $A\,C$. The curve joining the two points, G and 3, is called the expansion line and is a hyperbolic curve.

The manner in which the expansion curve may be drawn is shown in Fig. 2. Here $B\,C$ is the admission line; $O\,P$ the atmospheric line and $L\,R$ the vacuum line; as the clearance in the cylinder forms, of course, part of the admission volume, it must be considered in drawing the expansion line, since that line represents the variation of volume. Therefore, it is necessary to add to the vacuum line, $L\,R$, an amount, $L\,M$, which is determined by multiplying the length of $L\,R$ (or stroke) by the percentage of clearance. For example, if $L\,R$ is four inches and the clearance is six per cent., the length of $L\,M$ will be .24 in., or about ¼ in.

The steam is supposed to be cut off at the point C, and we wish to determine the shape of the expansion line to the end of the stroke. In order to do this, draw from the point M, a number of radial lines such as M_1, M_2, etc.; the points 1, 2, 3, etc., may be selected at will, but it is well to have them closer together near the beginning of expansion than at the end. Next, from where each radial line, as $M\,G\,D$, cuts the vertical line dropped from C, draw a horizontal line, as $G\,H$; and from where the radial line cuts an extension of the admission line, $B\,C$, draw a vertical line, $D\,H$. The intersection of these two lines will give a point of the curve, as H. *

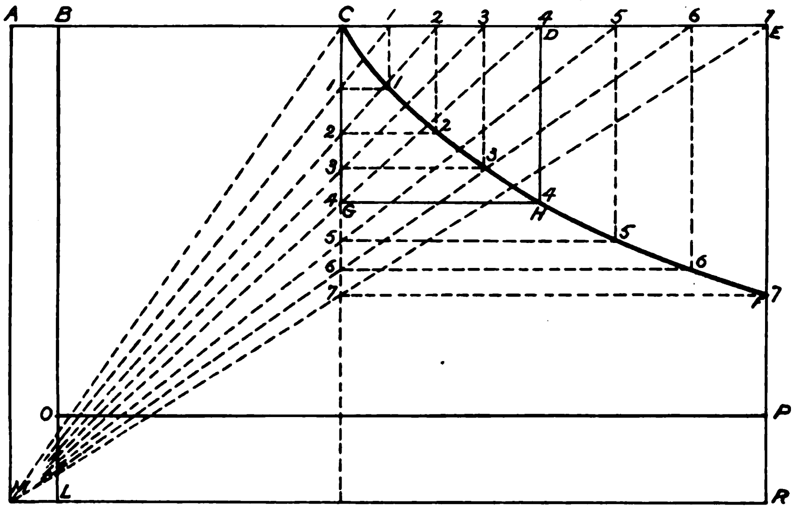

FIG. 2.—CONSTRUCTION OF EXPANSION LINE.

From Fig. 2 we find a very simple way of determining the ideal point of cut off of an indicator card. It will be seen that if we draw any radial line such as $M\,D$, and let fall from where it cuts $B\,E$ the admission line, a perpendicular line, $D\,H$; then if from where the perpendicular cuts the expansion curve we draw a horizontal line, $H\,G$, the point where this latter line cuts the radial line is perpendicularly below the point of cut-off or C; so that by drawing from G an upright perpencicular line it will pass through the ideal point of cut-off.

To apply the above, we will take the case of the indicator card shown in Fig. 3, to whose length $M\,L$ has been added, corresponding to a clearance of six per cent. Draw from M, a radial line of such as $M\,H$, and let fall from where this radial line intersects the extension of the admission line, a perpendicular line, $H\,C$; from where $H\,C$ cuts the expansion line, draw a parallel line until it intersects the radial line, $M\,H$, as at G; then drawing perpendicularly $G\,C$, the ideal point of cut-off is at C.

This construction means that, having chosen a given pressure, C, on the expansion line, then if the expansion of steam follows the law of perfect gases, the cut-off corresponding to the particular point, H, of the expansion line, is at C.

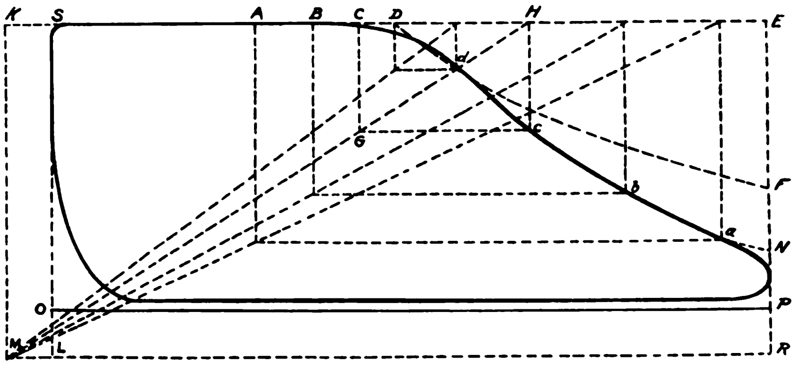

FIG. 3.—CARD OF FAST-RUNNING ENGINE.

In Fig. 3, four different points on the expansion curve have been thus chosen, a, b, c and d; and the corresponding points of cut-off found to be A, B, C, D. It will thus be seen that the steam in this case does not by any means follow the law which has been assumed. Let us assume that D is the correct point of cut-off and then by the construction above described draw the ideal expansion line, $D\,F$. It will be seen that the actual pressure drops much more rapidly than according to the law assumed, the final pressure being $R\,N$ above a vacuum instead of $R\,F$. At first sight it might appear that the cause of this was a leaky valve. It is more probable, however, that the drop in pressure is due to condensation of steam after the valve has closed; that is, the cold walls of the cylinder continue to condense steam,

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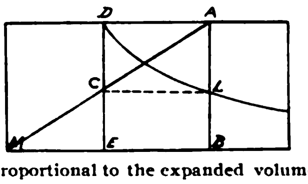
* The proof of this construction is as follows: From the two triangles, $M\,A\,B$ and $M\,C\,E$, we have $A\,B : C\,E = M\,B : M\,E$, or $\frac{A\,B}{C\,E} = \frac{M\,B}{M\,E}$. But $M\,E$ is proportional to the original volume of steam or V, and



$M\,B$ is proportional to the expanded volume at the point L, or V_1; on the other hand, $A\,B$ is equal to the initial pressure or P and $C\,E$ to the expanded pressure $L\,B$, or P_1. We have therefore $\frac{P}{P_1} = \frac{V_1}{V}$ or the curve is an equilateral hyperbola and represents an expansion according to Marriotte's law; that is, where the pressure varies inversely as the volume.

the walls at no time in the stroke having a temperature sufficiently high to re-evaporate any of this condensed water. By applying this method to indicator cards and determining several points of cut-off, as in Fig. 3, the reader will obtain an instructive lesson on the condensation of steam, even if it will not enable him to judge if his engine has or has not a leaky valve.

Fig. 4 represents a card from a Corliss low-speed engine, in which the point of cut-off, D, is determined as in the preceding case, and the expansion curve also drawn in the same manner, the clearance in this instance, however, being four per cent. In this case it will be seen that the ideal expansion curve corresponds much more nearly to the actual curve.

Indicator experts pretend to derive much information from the constructions just explained, and while they are useful, as stated before, in forming a basis for judgment, their direct indications are far from being precise, for the following reasons:

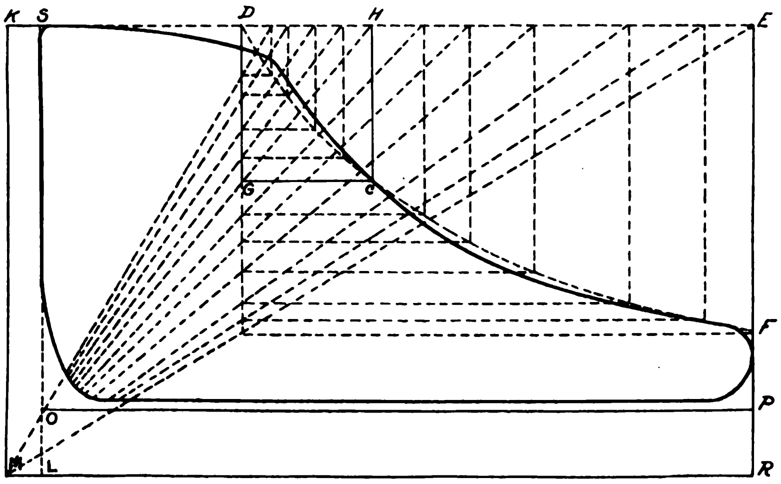


FIG. 4.—CARD OF SLOW-SPEED CORLISS ENGINE.

During exhaust the walls of the cylinder of an engine are cooled down to a temperature approaching that of the temperature of exhaust, and consequently at the beginning of the return stroke part of the steam admitted is condensed by the cool cylinder walls. This condensation may extend beyond the point of cut-off and, in some fast-running engines, undoubtedly occurs during the entire stroke; in addition, there is condensation resulting from expansion. In some cases, as in Corliss engines, and in some jacketed cylinders, as expansion proceeds the steam falls to a pressure corresponding to a temperature less than that of the walls of the cylinders, there being, consequently, re-evaporation. All of these factors influence the shape of the expansion line of cards, and as in fast running engines the amount of water remaining in the cylinders at the end of the stroke may correspond to from twenty to fifty per cent. of the entering steam, it is evident how great the distortions of this line may become.

The above constructions are, however, very simple, and are useful, at least, for comparative purposes, while they will have an indirect practical value to the engineer from bringing his mind into direct contact with matters that otherwise he would look upon as merely questions of abstract theory having no practical bearing.

THE ABSOLUTE ZERO.

That the zeros of the several thermometer scales in use are merely arbitrary points is well known. On the Centigrade and Reaumur thermometer scales, for example, the zero corresponds to the freezing point of water, while on the Fahrenheit scale it corresponds to the temperature which was supposed to be the lowest reached in the winter at the locality in Europe where the scale was originated. As references to the true or absolute zero are frequently encountered in steam literature, and particularly in connection with the efficiency of the steam engine, an explanation of its derivation and meaning may not be without interest.

In Fig. 1, the scales of the several thermometers in greater or less use are shown together, their arbitrary character being thus rendered plainly evident. It will be seen that on the Fahrenheit scale the range of temperature between the boiling and freezing points of water is divided into 180 degs., while the Centigrade and Reaumur scales have the same range divided into 100 degs. and 80 degs. respectively. It will also be seen that the zero of the Fahrenheit scale corresponds to —12.4 degs. of the Reaumur, and to —15.5 degs. of the Centigrade scale.

That temperature can go on decreasing indefinitely does not seem reasonable, and in point of fact, there is excellent cause for believing that an absolute zero of temperature exists; that is to say, a point below which temperature in the universe cannot fall. Calculations based upon such an assumption give results agreeing at all points with the results of practice, and consequently the existence of such an absolute zero of temperature has been definitely accepted. One of the methods by means of which the position of this zero point may be experimentally determined will be illustrated.

Suppose we have in a metal cylinder a quantity of air at the temperature of the boiling point, or 212 degs. F., and at a pressure of 100 lbs. per square inch above a vacuum, or 85 lbs. above the atmosphere. If, now, the cylinder be surrounded by a cooling mixture, it will be found that when the pressure of the air falls to 90 lbs. its temperature will be 145 degs; at 78 degs. the pressure will have fallen to 80 lbs., at 10 degs. to 70 lbs., at the zero of the Fahrenheit scale to 68 lbs., and to 60 lbs. at —57 degs.

Referring to Fig. 2, let us lay down the temperatures thus obtained to scale on a horizontal line, MC, and represent the corresponding pressures to scale by vertical lines, as AM and BC. It will now be found that a straight line can be drawn through the ends of the vertical lines, and if we continue this line, AB, until it cuts the continuation of the horizontal line, MC, then by drawing further vertical lines, as DE, we can obtain the values of pressures corresponding to temperatures beyond the limit of observation—upon the assumption, of course, that at lower temperatures air will follow the same law as at higher ones. It will be seen from the diagram that the pressures continually and proportionately decrease with the temperatures, and, finally, at the point O, pressure ceases to exist. This is the point of absolute zero, and if the line, MC, has been drawn to scale, the continuation, CO, will also be to scale, thus enabling the distance of the point below the arbitrary thermometer zero to be determined by simple measurement. On the Fahrenheit scale this will be found to be—460 degs., and on the Centigrade scale —273 degs. Temperatures considerably below —300 degs. F have been obtained in the liquefaction of gases.

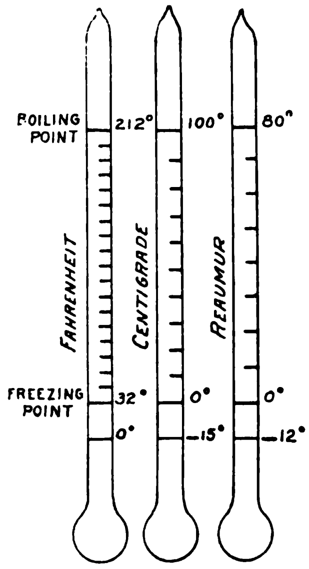


FIG. 1.—COMPARISON OF THERMOMETER SCALES.

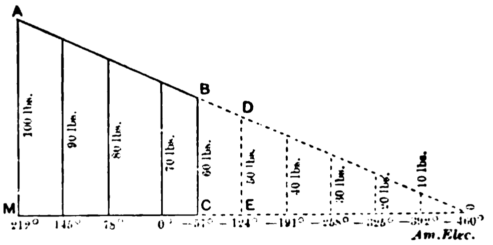


FIG. 2.—DETERMINATION OF ABSOLUTE ZERO.

* * *

Acetylene Gas as a Poison.

An objection urged against acetylene gas on account of its poisonous nature has been met by an advocate of that gas with the assertion that ordinary illuminating gas is seven times more poisonous. The implication that therefore acetylene gas is not dangerous is no more justified than would be a similar inference with respect to arsenic from the statement that prussic acid as a poison is many times more acute than arsenic.

A BIOGRAPHICAL HISTORY OF ELECTRICITY.

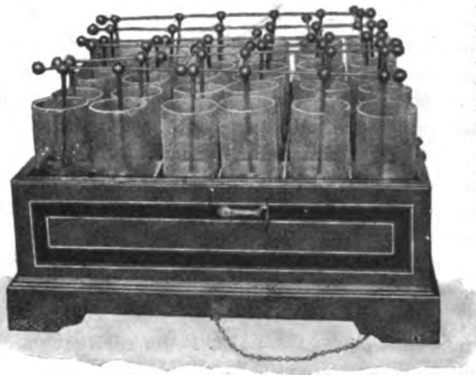
Dufay was the first to draw a spark from the human body, and Priestley informs us that this experiment formed a "principal part of the diversion of ladies and gentlemen who came to see experiments in electricity"—the new science during the middle of the eighteenth century having been accorded a social standing. The brilliant French savant also established the principles of electrostatic induction, the phenomena of which had been faintly recognized by Guericke and Gray. His greatest achievement, however, was, in his own words, the discovery of "two distinct kinds of electricity, very different from one another; one of which I call *vitreous* electricity and the other *resinous* electricity." This was the beginning of the theories of fluid electricity which, though receiving a death-blow at the hands of Faraday, lingered until within recent years, and are yet useful for illustrative purposes.

The work of Gray and Dufay ended about 1737 and the next epoch commences with the discovery of the Leyden jar in 1745 and extends to the time of Volta, who stands as sponsor for modern electricity. Von Kleift, dean of a cathedral at Camin, Pomerania, discovered that when a liquid was placed in an apothecary's vial and the glass then electrified, a powerful shock was experienced if the vial was held in one hand and the liquid touched with a finger of the other. In January, 1746, Musschenbrook, a professor at the University of Leyden, Holland, independently made the same discovery, and presently experimenters in the various scientific circles of Europe were performing all manner of startling experiments with this first considerable source of electrical energy that had come into possession of man. It was by reading a theory offered by Watson to explain the action of the Leyden jar that Benjamin Franklin was attracted to the study of electricity.

While the work of Gilbert, Guericke, Hauksbee, Gray and Dufay has more or less intrinsic value from the scientific point of view, and though it formed the foundation upon which others built and, above all, furnished inspiration that led to wonderful advances, it was left for an American—perhaps the greatest our country has produced—to make the first real practical application of electrical knowledge. With Benjamin Franklin was first brought into electrical investigation the modern practical spirit which is not satisfied with mere brilliant experiment and lofty speculation, but has for its final aim the adaptation of nature's phenomena to the service of man.

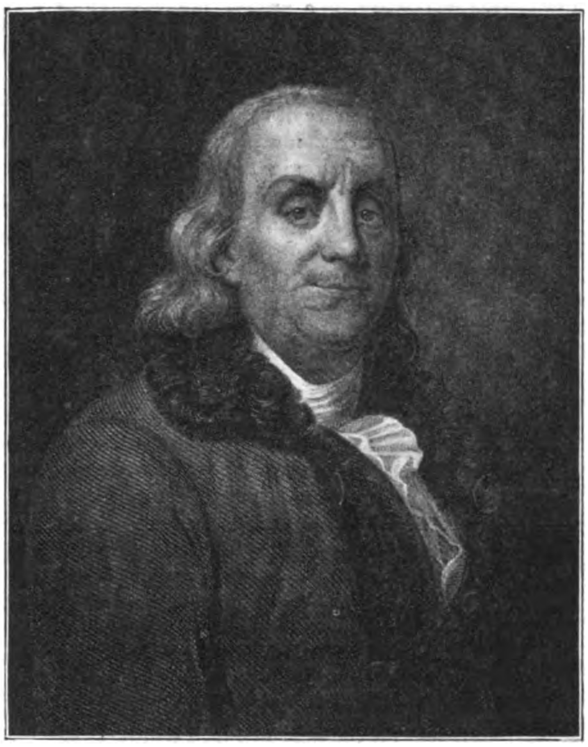
The impression which the work of Franklin produced in Europe was remarkable. Referring to the several letters published between 1747 and 1754, which cover the period of his great electrical investigations, Priestley, in his celebrated "History of Electricity," published in 1759, says:

"Nothing was ever written upon the subject of electricity which was more generally read and admired in all parts of Europe than these letters. There is hardly any European language into which they have not been translated; and, as if this were not sufficient to make them properly known, a translation of them has lately been made into Latin. * * Though the English have not been backward in acknowledging the great merit of this philosopher, * * to form a just idea of the great and deserved reputation of Dr. Franklin, we must read the foreign publications on the subject of electricity; in many of which the terms *Franklinism*, *Franklinist* and *Franklinian system* occur on almost every page."



FRANKLIN'S LEYDEN JAR BATTERY.

When we consider this was written by a great European scientific authority concerning a man previously unheard of in science, and living in a new world less known to Europe than Argentine is to us at the present day, its full import can be appreciated.



BENJAMIN FRANKLIN.

Franklin's first experiments were with the Leyden jar, to charge which he constructed a glass static machine of his own design. He discovered, by a beautifully scientific series of experiments, that the power of giving a shock lies in the glass itself and not in the metal coatings. As a deduction from his theory of electricity, he concluded that jars might be coupled together and thus produce an effect in proportion to the number used, and upon this principle he constructed batteries of such power that he was led to write: "There are no bounds to the force man may raise and use in the electrical way; for bottle may be added to bottle and the greatest known effects of common lightning may, I think, without much difficulty be exceeded in this way." The accompanying illustration shows a Leyden battery made by Franklin, and which is still in use at Dartmouth College. A static machine also made by Franklin, is in possession of the Franklin Institute, Philadelphia.

Franklin held that that there is but one electric fluid, which ordinarily exists in a body in a state of equilibrium; if some of the fluid is drawn off, the body exhibits negative properties, or positive properties if added to. This first complete theory of electricity held sway for more than a century, though in inner circles known to be untenable since the day of Faraday.

Franklin, however, is best known through his identification of lightning with electricity. Though there had been many speculations on this subject, notably one by the versatile Abbé Nollet, none was so definite as that put forth by Franklin in 1748, and finally, in 1749, he proposed in detail an experiment to determine the question whether clouds that contain lightning are electrified or not, and at the same time laid down the principles of the lightning rod which were held up to within a very recent period.

Franklin was, unfortunately, delayed in making the famous experiment he described, which was first done by Dalibard, May 10, 1752, in France, after the indications contained in Franklin's Collinson letter of July, 1750. During the latter part of the month of June of the same year, before the news of the French experiment had, according to Priestley, reached America, Franklin performed his celebrated experiment of drawing electricity from the clouds by means of a kite. A similar experiment with a kite was successfully tried in France by De Romas early in July and, it is claimed, before the news of Franklin's experiment had reached Europe.

According to Franklin's celebrated theory of the lightning rod, a pointed rod gradually draws off the electricity in the atmosphere, thus dissipating a charge before it becomes formidable. Some distinguished European savants disputed the superiority of pointed lightning rods, which gave rise to the famous "points *vs.* knobs" controversy. Franklin defended his views with the remarkable skill which he invariably displayed, whatever the occasion, and emerged from the controversy an acknowledged victor. As a lightning discharge is now considered to be due to the breaking down of the air between the object struck and a charged cloud through the existence of an enormous dielectric stress, this theory is no longer tenable.

In Portsmouth, N. H., a lightning rod put up under the direction of Franklin is still in use, consisting of an iron rod about a half inch in diameter.

LESSONS IN PRACTICAL ELECTRICITY

The principles illustrated in the example of dynamic generation of E. M. F. in the axle of a railroad train cutting the earth's lines of force, applies to all forms of dynamo electric machines. In so-called unipolar dynamos, which will be considered later, the E. M. F. is generated by a continuous cutting of lines in the same direction, as in the case of the axle of a train. For reasons, however, that will be apparent later, this form of machine is not adapted for the generation of high E. M. Fs., and besides possesses mechanical disadvantages.

In the usual dynamo electric machine the flux of lines of force is highly concentrated, being some thousand times more dense than that of the earth's field, and is utilized in the air gap between the pole pieces and the core of the armature. Referring to Fig. 1, the lines of force coming from the pole marked *N* cross the air gap, enter the core, through which they pass to the other air gap, and crossing, enter the south pole—the magnetic circuit being completed by the field cores and yoke of the dynamo frame. It will thus be seen that the working portion of the magnetic circuit is in the air gap, the armature wire cutting through the lines concentrated there in the same manner as the train axle cuts through the earth's lines of force. The illustration shows but a single wire, the machine thus being a dynamo reduced to its simplest form.

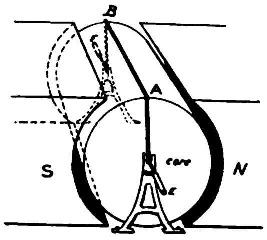


FIG. 1.

Referring to Fig. 1 and also to Fig. 3, it will be noted that when the wire (which we will suppose revolves about the armature core, the latter being stationary) is passing from *A* to *B*, a minimum number of lines of force are cut, whereas in passing from *I* to *J* a maximum number of lines are cut. It is also apparent that when the wire passes *J*, the E. M. F. generated will begin to decrease until at the point *N* the same condition exists as at *A*, and the E. M. F. again becomes zero. In passing from *N* to *M* the lines of force will be cut in the reverse direction, so that the E. M. F. generated on this side of the core will be negative, if the E. M. F. is counted positive on the other side. It will thus be seen that a single wire of a dynamo, with the lines of force disposed so as to be best cut by a revolving wire, will generate alternating E. M. Fs.—that is, E. M. Fs. which increase from zero to a maximum, then drop from a maximum to zero, then continue to decrease to a negative maximum and finally rise again to a zero value at the original starting point.

In Fig. 3 a quadrant of the circumference of the armature core is divided into ten equal parts, and one hundred lines of force are represented as passing through the air gap in this quadrant—which gives a total of 200 in each air gap. Suppose now that the wire passes through each of these equal divisions in one second; that is, from *A* to *B* in one second, requiring ten seconds to pass from *A* to *J*. Then in the first second but 1.2 lines of force will be cut by the wire; in the second second (from *B* to *C*) 3.6 lines, while in the tenth second (from *I* to *J*) 15.6 lines will be cut.*

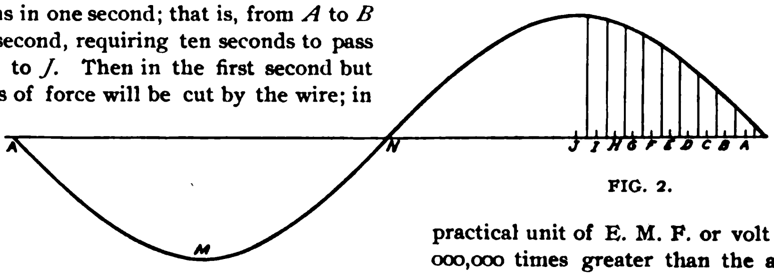


FIG. 2.

As the E. M. F. generated is measured by the number of lines cut per second, then the E. M. F. generated during the first second will be 1.2 absolute units; in the second second 3.6 absolute units, and in the tenth second 15.6 absolute units. The accompanying table shows the E. M. F. for each second.

TABLE I.—E. M. F. IN ABSOLUTE UNITS.

A	B	C	D	E	F	G	H	I	J
1.2	3.7	6.0	8.2	10.2	12.0	13.4	14.5	15.2	15.6

Fig. 2 shows a curve which has been laid down by using the above E. M. Fs. as ordinates. As the field in the second quadrant will be the same as in the first, the second quarter of the curve is merely a duplicate of the first, but a falling instead of rising curve since the field is decreasing. The lower half of the curve will, of course, be a duplicate of the upper half, as the same manner of cutting will occur from *M* through *N* to *A*, but, as stated above, in a reverse direction, thus making the E. M. F negative. The curve shown in Fig. 3 is known as a sine curve.

We will now take the case of a machine in which the density of the lines of force and the rate of cutting much more nearly approach those of practice. We will assume that the armature is ten inches in diameter and twelve inches long, which will give a total area of 120 sq. ins. through which the flux passes. We will also assume that the wire in Figs. 1 and 3 makes 1800 r. p. m. or thirty per second Finally, we will assume that the density of the lines of force is 80,000 per sq. in., thus making a total flux of 120 × 80,000 = 9,600,000 lines instead of 200 as in Fig. 3, or 48,000 times greater.

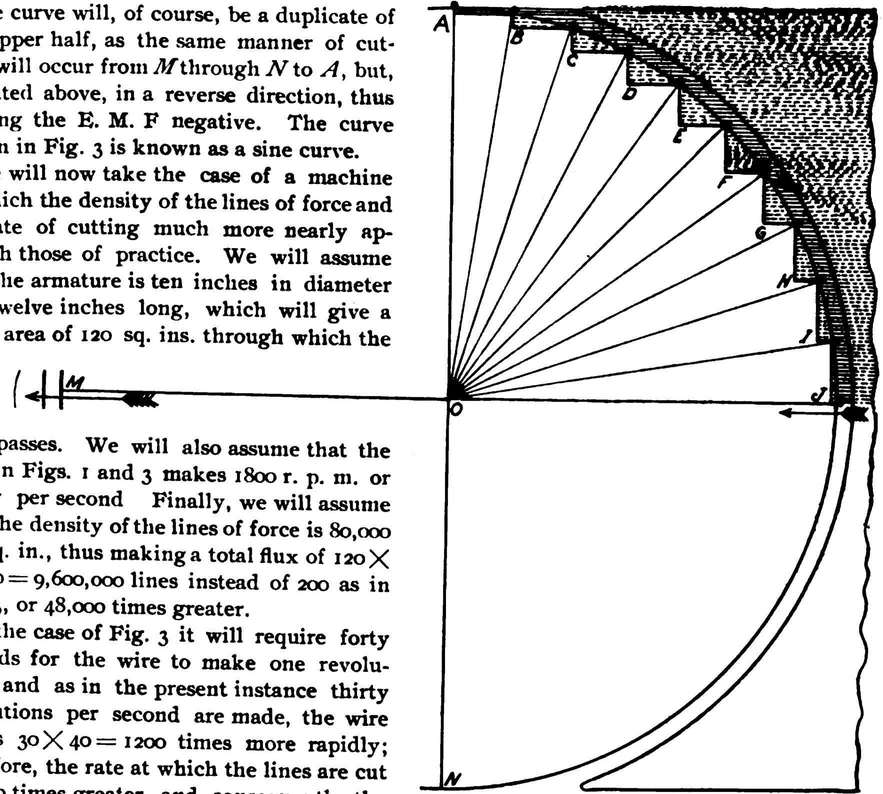


FIG. 3.

In the case of Fig. 3 it will require forty seconds for the wire to make one revolution, and as in the present instance thirty revolutions per second are made, the wire moves 30 × 40 = 1200 times more rapidly; therefore, the rate at which the lines are cut is 1200 times greater, and consequently the E. M. F. with the field of Fig. 3 will be 1200 greater.

But the lines of force are also more dense, so that through this the E. M. F. is still further increased or, as just shown, will be 48,000 times greater. The total increase is thus 48,000 × 1200 or 57,600,000 times. If, therefore we multiply the numbers of Table I, by this quantity, we will have the values of the E. M. F. generated in the second case, but also expressed in *absolute units*. As the practical unit of E. M. F. or volt is 100,000,000 times greater than the absolute or C. G. S. unit, we must divide by that number in order to reduce to volts; performing both the above operations, we have, finally, the following table of E. M. Fs., in volts, generated in the second case:

TABLE II.—E. M. F. IN VOLTS.

A	B	C	D	E	F	G	H	I	J
.8	2.1	3.5	4.7	5.9	7	7.7	8.3	8.7	9.0

The curve of Fig. 2 also represents the above E. M. Fs., but to another scale.

It can be readily seen that if the wire of Fig. 1 were made in the form of a loop, so that while one side were going down from *A* to *J*, the other would be going up on the opposite side from *N* to *M* and also having an E. M. F. generated in it; moreover, since the two E. M. Fs. would be opposite in direction looking at one end of the core, they will be in the *same* direction in the loop and therefore would be added together, and by having a number of turns the E. M. F. would be still further multiplied. The machine described is, therefore, an elementary alternator, though not of a commercial form. In another article the manner in which continuous currents are derived from such an alternator by adding a commutator will be described, as well as the form of commercial alternators.

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* These values have been determined by trigonometry, as the geometrical method shown is not sufficiently accurate to obtain exact values.

Letters from Practical Men

A Safe Soft Solder Flux.

As a manufacturer of a "Safe Soft Solder Flux," I have some diffidence in replying to the letter on that subject in the July issue of the AMERICAN ELECTRICIAN, yet I feel that the implication in regard to the non-existence of a flux corresponding to the requirements there enumerated should not be permitted to remain unchallenged. I am, unfortunately, prevented by trade considerations from giving the composition of the soldering paste or flux to which I refer, and can therefore merely state that there is on the market at the present time at least one flux which answers the requirements pointed out in the letter in your July number.

J. F. KESTER.

All that can be asked of an ideal soldering flux is that it shall be non-corrosive, convenient and effective. Ordinary soldering salts and fluids are effective, but they are corrosive, ruining both work and tools. They are not convenient, since a man using a soldering fluid always expects to spill it before he leaves a job, and wherever it is spilled its mark is left.

An ideal soldering flux should be inert at ordinary temperatures. When heated it should unite chemically with the oxides of the metals to be soldered, and then flow to the lowest point, carrying the oxides with it. It should leave a thin coating upon the joint impervious to atmospheric influences, thereby preventing future oxidization and corrosion. It should be solid at ordinary temperatures.

Such a soldering flux is now on the market and can be obtained of all electrical supply houses.

L. B. ALLEN.

A Peculiar Accident.

At 12.30 P. M., July 19, a common "Yaller" dog stepped on the main driving belt in the Elk Street station of the Buffalo General Electric Company, and was promptly carried under a twenty-foot flywheel driving a seventy-two-inch belt driven by an Allis tandem Corliss engine (48 ins. stroke × 26 ins. and 52 ins. diameter). At the back of the wheel there is but three inches clearance between the pulley and an iron floor which rests on a five-inch I-beam built in the stone and cement foundation on either side. This was torn out of the foundation and the belt torn in two places, besides having a number of holes made in it which had to be patched. The belt in swinging up caught a three-inch T-beam, which was but eight inches from an arc circuit, and tore down the beam, leaving the wires intact; the beam in falling narrowly missed braining one of the assistant engineers. Strange to say, the dog was but little mutilated, although instantly killed.

When the belt broke this threw the whole load, consisting of some 2700 arc lamps, on a cross compound Allis-Corliss engine, 30 ins. and 56 ins. × 60 ins. stroke, and with a twenty-eight-foot wheel; this engine carried the load the remainder of the night, there being no interruption of the service. This accident also broke the lightning apparatus and sprung the shaft out of line.

HARRY HOERLE.

Roentgen Ray Experiments.

I am operating a three-inch induction coil made like the one described in the May number of the AMERICAN ELECTRICIAN, the coil giving a vigorous, continuous 3¼-in. spark if carefully made and suitably energized. I find a coil of this size amply large for Röntgen ray experimental work. Excellent radiographs may be obtained of the lower limbs, arms, neck, etc., by using an ordinary dry plate and holder, or by propping a plate against the top of a box, and laying an object on the top of a box over the plate. By the aid of a fluoroscope made according to the directions given in the June number of the AMERICAN ELECTRICIAN, I have been able to observe the heart beat and to see an outline of the spinal column through the thickness of the clothed body.

Collodion varnish or gum arabic paste are excellent for affixing the calcium tungstate to the screen, which then requires several days to dry out properly. Merck's tungstate of calcium for Röntgen ray screens, may be obtained through any druggist for about sixteen cents for an ⅛-oz. vial, which is amply sufficient to make a screen. There is no appreciable advantage in using a larger coil than the above with the fluoroscope, as I can see quite as well with my coil as I can with one giving a six-inch spark, although radiographs may be made with the larger coil in less time. If a 110-volt electric light circuit is accessible, a ten-ohm resistance may be put in the circuit and a shunt taken from the resistance, allowing about twenty volts at the coil.

A bichromate battery may be made from some large candy bottles cut down to hold a quart of fluid, using for elements the carbon and zinc cylinders from old dry batteries. I have obtained excellent results with the Crookes tubes made by Queen & Company, Philadelphia.

H. J. GOODING.

Engine Belted Governors.

As an illustration of what great expense may be caused by neglect of a simple precaution, the following incident may interest your readers. In a certain central station where four 50-light arc machines were belted from the same engine countershaft, the circuit of one of the machines opened one evening, and on account of the sudden jump in speed, or from some other reason, the belt running the governor parted about the same time. Before a man could get to the engine throttle, no less than three of the dynamos were wrecks, the armature windings having been stripped. The cause, of course, was the run-away speed of the engine, which increased as each succeeding arc machine was wrecked. It can be imagined what a sight the arc machines presented with their armature windings tangled up between the field poles. If a gravity safety drop had been used in connection with the governor belt, as it should have been, the company would have been spared an expense of a good many hundred dollars, and the town where the accident occurred, saved from darkness for several nights.

L. T. STORRS.

A Queer Phenomenon.

Several years ago a house electrician related to me a singular experience, and have never yet been able to obtain an explanation of the strange effect he noticed. The electrician was engaged in testing out a defective electric gas-lighting circuit, and in order to assist in locating the leak by means of the accompanying spark, he had an assistant turn the static generator while he made an examination in a dark attic. To his astonishment, he found the entire length of the wire in the attic luminous, the light given off being similar to that of a vacuum tube. I feel sure that an explanation from one of your readers of this singular phenomenon will be read with interest.

R. T. KENYON.

Eddy Current From Stray Field.

A peculiar incident occured in the course of my practice in dynamo design, which may interest your readers. Our firm had been for a long time making a smooth-body drum armature, consisting of disks set upon the shaft with thick end disks and large nuts. The armature heads were of the overwound type, and we had trouble with the frequent burning out of the heads next the pulley. For a time we were at a loss to account for it. As we gradually improved our machinery, we adopted the Eickemeyer winding, which left this large nut at the end of the armature bare. From that time on we had no trouble. One day when testing one of the machines of this type, I happened to feel this nut. It was so hot that it scorched my fingers, and I was quite severely burned. This heat was evidently caused by the eddy currents generated in it by the stray field. herein might lie the explanation of similar trouble noted by others.

ENGINEER.

Polarity Tester.

I read in the June issue of the AMERICAN ELECTRICIAN the letter from Mr. J. H. Keim, Jr., describing a simple polarity tester, and while I have no doubt but that the solution given is very good—in fact I know it will do as claimed—yet I think I am using a more simple solution. This consists of ten parts of distilled water to one of iodide of potassium. I use distilled water to improve the keeping qualities of the solution. With this solution applied the same as Mr. Keim's (with paper) the positive pole is shown by a brown mark on the paper, and the action is instantaneous; it can be used with distance proportions about the same as with Mr. Keim's tester, and for any reasonable voltage. I have been using the iodide solution for about eight years and find it the best I have tried. Instead of water to dampen the paper, the user may dampen it with his mouth without the least fear, as it is perfectly harmless.

BEN W. CLARK.

ELECTRICAL CATECHISM

32. How can one tell whether the different parts of a dynamo are properly connected?

The simplest way is to compare the connections with the direction sheet and diagrams sent with the machine by the maker. If these are lacking, examine the machine and see whether it is series, shunt or compound wound. Then connect the field coils in series or in shunt with the outside circuit as the case may be.

33. How can you tell whether a machine is series, shunt or compound?

The name plate on the machine often tells. When it gives both the volts and amperes, the machine is for constant potential and is either shunt or compound wound. When the name plate gives simply the current, as 6.8 or 9.6 or 10 amperes, the machine is intended for constant current, and the field coil is to be connected in series with the armature. Another method is to examine the size of wire on the armature and field. If the field wire is larger than, or the same size as, the armature wire, the field and armature are intended to carry the same current and should be connected in series, as indicated in Fig. 33*a*. If the field wire is much smaller than the armature wire, the field is intended to carry only part of the whole current, and it should be connected in shunt with the main circuit, as indicated in Fig 33*b*.

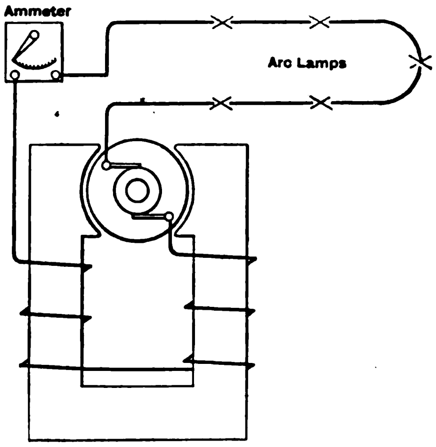


FIG. 33*a*.

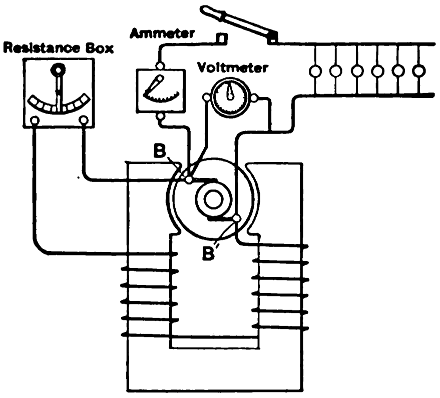


FIG. 33*b*.

34. How can one tell whether the connections between the armature and field coils are reversed?

If the machine picks up all right when brought up to full speed, the connections are proper. If it does not pick up, the field coils may be wrongly connected. This may be tested by a voltmeter connected across the armature terminals, as indicated in Fig. 33*b*, or by a compass needle placed a short distance from one of the pole pieces of the dynamo in such a position that it no longer points to the north. If the machine is up to speed when the circuit through the field coils is open, the voltmeter will indicate a few volts due to the residual magnetism of the iron field frame, as explained in *11* (AMERICAN ELECTRICIAN, June, 1896, page 68). If the field coils are properly connected, this initial voltage will send current through the field coils in such a direction as to strengthen them and so cause a higher voltage in the armature. On the other hand, if the field coils are improperly connected, the current due to the initial voltage weakens the field magnetism and so prevents the machine from building up. This will be indicated by the initial voltage becoming less when the field circuit is closed; also by the needle of the compass being less strongly attracted.

35. When a dynamo has several field coils, should the coils be connected in series or in parallel?

The different coils are almost always connected in series with one another so that the same current passes through each coil. The exceptions to this rule are that, of course, the series coils of a compound dynamo are connected in series with the main circuit, and the shunt coils carry only part or none of the current passing through the series coils. Again, in some large compound wound dynamos, the different sections of the series field coils are connected in parallel or may be connected either in parallel or in series.

36. What will happen if some of the field coils are reversed?

If half of the coils oppose the other half, the machine will not pick up at all. If one of four or more coils is opposed to the others, the machine may pick up, but the voltage will be low and some of the brushes will spark badly.

37. How can one tell which coil is reversed?

There should be an equal number of "north" and "south" poles in the field. This may be tested by a pocket compass. If there are more poles of one kind than the other, it indicates that some of the coils are reversed. In nearly all machines the poles should be alternately north and south. An exception to this rule is the old Sperry arc machine which had two north poles together and two south poles together.

38. In connecting up a dynamo for the first time, how can one be sure to connect the different coils in the right direction?

If you have no direction sheet or diagram, or if the terminals of the different coils are not made so as to indicate the method of connection, get a few cells of battery and a pocket compass. See if the residual magnetism in the poles is alternately north and south. Send a small current from the battery through one of the coils and note which end of the coil must be connected to the zinc or negative terminal of the battery in order to strengthen the residual magnetism. Mark with a string or bit of paper the negative end of each coil as thus found. Connect the marked end of one coil to the unmarked end of its neighbor, continuing thus until only two ends are left as the terminals of the entire series. These are then to be connected with the armature as indicated above in *34*.

39. How can one tell by a compass needle whether a magnet pole is getting stronger or weaker?

Place the needle near enough to the pole so that it is deflected considerably from pointing north and south. With the compass remaining in the same place, the needle will be deflected further from the north and south line as the magnet pole becomes stronger, approaching a limit when the needle points east and west. If the needle is disturbed, so as to vibrate from side to side, it will be found that the needle vibrates faster as the magnet pole gets stronger, or as the needle comes closer to the pole.

40. How may a dynamo lose its residual magnetism?

By rough handling or by long standing unused, the magnetism becomes weakened. Sometimes the armature reaction due to a heavy short circuit will demagnetize or even reverse the field magnet. Sometimes also the induction current due to lightning will demagnetize or reverse the field.

41. How may the field magnetism become reversed?

By lightning or short circuit as mentioned above in *40*. Dynamos when not working sometimes become reversed by the stray magnetic field of other dynamos near by.

42. When the residual magnetism is lost, how can one make a dynamo pick up?

The field may be temporarily magnetized by current from another dynamo. Even a few cells of battery will sometimes send enough current through the field coils to set up sufficient initial magnetism to allow the machine to build up. (Of course the battery circuit should be broken before the machine comes up to full voltage.) Sometimes one end of a bar magnet held against one of the pole pieces will magnetize the field enough for a start.

43. Will a dynamo pick up if the residual magnetism is reversed?

Yes. The initial voltage is reversed, the initial current through the field coils is reversed and the machine builds up with its voltage reversed. The current delivered by the machine is, of course, reversed, and trouble will occur if one attempts to connect the dynamo in multiple with other machines not reversed. If the machine is supplying arc lamps, they will be reversed also and will throw their light upward instead of downward.

QUERIES AND ANSWERS

How will the action of a motor or dynamo differ if the machine is short-circuited in one case or grounded in another? A. Y. Y.

A short circuit will at once manifest itself by sparking, a burn-out or otherwise, while a single ground in circuit will not affect the working of the machine in any manner. A short circuit may be considered as a double ground.

Why are underwriters' rules so opposed to a trolley circuit being used for lighting and power in stores and dwellings? Galveston.

The use of the trolley current in a building is entirely indefensible, for the reason that every part of the building would thereby form one side of a 500-volt circuit. Should the insulation be weak at any point or be crossed by a conducting material, a fire would be likely to occur, particularly in the presence of dampness.

Which pole of the earth is the true magnetic north? O. F. L.

If the north-seeking pole of a magnet is called a north pole, then the true magnetic north pole of the earth is in the southern hemisphere. Notwithstanding the contradiction, the pole in the northern hemisphere is called the north pole, and it is improbable that the designation of the poles of the earth or of magnets will ever be changed to conform to correct nomenclature.

1°. In recharging a storage battery, how should it be connected to the charging current with respect to poles? 2°. If in recharging, the battery should be wrongly connected, would it be injured? 3°. Can the efficiency of a storage battery be improved at any time by reversing the plates, as above? A. V. Y.

1°. The positive or brown plates should be connected to the positive pole of the dynamo. 2°. Cells of pasted or composite plates would be injured, and also Planté plates in that the negative would be weakened through undergoing a positive formation. 3°. After either composite or Planté plates are properly formed, their efficiency will not be increased by reversal, but most probably decreased.

1°. What is the E. M. F. of the ordinary magneto? 2°. Why is not the armature of a magneto burned out on short circuit? O. F. L.

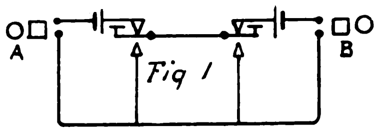
1°. Assuming that the ordinary magneto will ring through 5000 ohms, and that the current necessary to ring the bell is 1-100 ampere, the E. M. F. generated will be approximately, 50 volts. In strong testing magnetos there may be 200 volts generated. 2°. As the usual form of magneto generates an alternating current and has an armature of high inductance on account of the many coils of its winding, the current on short circuit cannot attain a high value, being "choked" by the inductance.

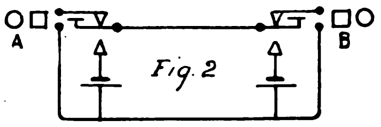
In rewinding a field or armature of a machine, what is the result of putting more or less wire on one coil than on another? A. V. Y.

In case of an armature, lack of electrical balance will cause sparking, and should, therefore be carefully avoided. As far as the magneto-motive force generated by the ampere-turns of a bipolar field is concerned, the entire coil might be on one core, leaving the other bare, the case being similar to that of an E. M. F. in an electrical circuit. The coils of consequent pole and multipolar fields should be balanced, as otherwise there will be short-circuiting of lines of force—the case being similar to two or more E. M. Fs. placed in parallel. Considerations relating to heating, magnetic leakage and minimum resistance and weight of copper, make a uniformly distributed winding desirable in every case.

Please give connections for two bells, A and B, such, that when the button at B is pushed A will ring, and when the button at A is pushed, B will ring. F. R. S. and W. H. W.

One method is shown in Fig. 1 and another in Fig. 2. In the former the battery at the far station, say B, rings the bell at A; in the other each battery is local, which gives the latter an advantage, but one perhaps overbalanced by the fact that both batteries are always in closed circuit; for though connected in opposition so that one "backs" against the other, any reduction in voltage at either battery will cause current to flow through the circuit. The buttons used should be double-contact pushes. If these cannot be procured, either a double-contact strap switch or a simple two-point switch may be used. By following the connections it will be seen that the push or switch contact must rest against one point when not used, and be pressed against the second point when ringing the distant bell.





If five 100-volt lamps are connected in series on a 500-volt circuit, what is the voltage at the first lamp, fifth lamp, and at the line after leaving fifth lamp? C. E.

The voltage *between* the terminals of each lamp is one hundred. As to the final query, a point cannot have a voltage, properly speaking. The confusion shown in the query between potential and voltage should be avoided. Assuming that the negative terminal of the dynamo has a potential of zero, and the line no resistance, then the positive terminal has a potential of 500, the far extremity of the first lamp a potential of 400, and the line connection of the last lamp a potential of zero. In practice, however, it is never necessary to consider potentials, as difference of potential or E. M. F. is what is practically dealt with. By keeping in mind the idea of voltage "drop," the more abstract idea of potentials may be dismissed entirely. For instance, in the above case, there is a free voltage of 500 in circuit, generated at the dynamo, of which one hundred volts (=C R) is dropped in the first lamp, due to its resistance to the current passing, one hundred in the second and 500 in the five lamps, the free voltage being thus all used up.

The load being constant, why does the speed of a series motor vary directly with the applied E. M. F. O. F. L.

Suppose we have a separately excited dynamo; then, neglecting armature reaction, the E. M. F. will vary directly as the speed. Conversely, if we have a separately excited motor, its speed will vary with the applied E. M. F., and the same, of course, will be true of a series motor with a saturated field. The following is a more direct explanation: Since the load torque is constant, the armature torque must be constant; the armature torque is proportional to the product of the field by the current, and as the field is also assumed constant, the current must be constant; the value of the current is $\frac{E-e}{R}$ where E is the applied E. M. F. and e the counter E. M. F., and as R is a constant, $E-e$ must be a constant; but e is the product of the field by the speed, and as the field is assumed constant, the speed must rise in the same proportion as the applied E. M. F., in order that $E-e$ may remain constant. As will be seen, the above only applies strictly to loads requiring a current that will saturate the field. For very small loads, the speed will vary more nearly as the *square* of the applied E. M. F.

1°. What is a "microhm"? 2°. What is resistivity? 3°. In "Lessons in Practical Electricity," page 102, July issue, how was the resistance of the iron circuit found? C. G. N.

1°. A "microhm" is the millionth of an ohm. 2°. The resistivity (or specific resistance) of a metal or other substance is the resistance of a piece of that material one centimetre long and of one square centimetre area—that is, the resistance between two opposite faces of a centimetre cube. Expressed in English measure, the equivalent of resistivity is the resistance of a block of the material 2.54 ins. long and having an area of one square inch. 3°. The circuit referred to has a length of 142 ins. and a diameter of 3 ins. (area = 7.0686 sq. ins.), the resistivity of the steel of which it is composed being 15.803 millionths of an ohm or 15.803 microhms. First, disregard the microhm and consider the resistance of a length of 2.54 ins. to be 15.803 ohms; then the resistance of 124 ins. $= \frac{142 \times 15.803}{2.54} = 883$ ohms, which would be the resistance if the area were one square inch. Second, as the area is 7.0686 sq. ins., the resistance becomes $\frac{883}{7.0686} = 125$ ohms. Third, as the resistivity is in microhms we divide by one million, and have $\frac{125}{1,000,000}$ ohm. The simpler way is to turn the length into centimetres and the area into square centimetres; then, multiplying the resistivity by the former and dividing by the latter, we have the result at once. Thus, 142 ins. = 360 centimetres and 7.0686 sq. ins. = 45.6 sq. centimetres; $\frac{15.803 \times 360}{45.6} =$ 125 microhms, as before. The resistivities of different materials are given—sometimes under the head of "specific resistances"—in many text books and pocket books, and from metric conversion tables may be picked the centimetres and square centimetres corresponding to the English measures.

New Apparatus and Appliances.

A CHEAP WHEATSTONE BRIDGE.

One of the instruments most indispensable to the electrician is the Wheatstone bridge, but heretofore the price of this apparatus has in most cases been prohibitive. The accompanying illustration, however, represents a type which is sold at a low price, and is yet claimed to be an efficient instrument, specially designed for practical use by practical men.

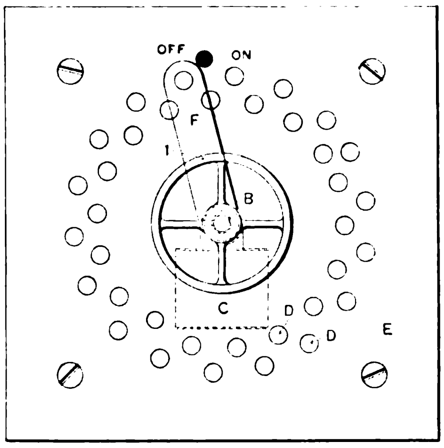
The galvanometer is so constructed that it may be revolved independently of the engraved hard-rubber face plate, thus enabling the zero to be easily and quickly set. One of the practical advantages claimed is the quickness with which readings may be taken, being much greater than with the usual plug bridge. The lever arms are of bronze and so designed as to always insure efficient contact. The bridges are made in two styles, No. 1 and No. 2. The range of reading in No. 1 is from .01 ohm to 1,100,000 ohms, and in No. 2 from .01 ohm to 11,000,000 ohms. Both are the same in price, the No. 1 set, however, having proved the more popular, except for unusually high resistances.

WHEATSTONE BRIDGE.

The above described Wheatstone bridge is made by K. G. Cummings, Monadnock Block, Chicago, Ill.

MOTOR STARTING BOX.

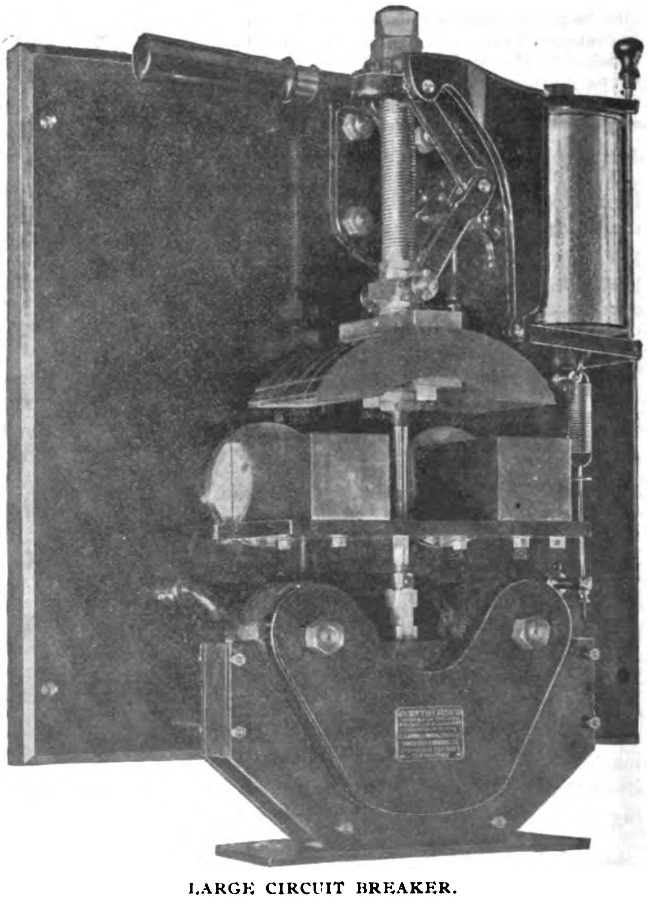
The accompanying sketch shows diagramatically a motor starter designed by F. P. DeWilde, of Sheboygan, Wis., the main feature of which is an automatic motion whereby the handle is brought to its initial position, whatever the position of the contact arm, whenever the switch of the motor is opened. In the illustration, *A* represents the usual rheostat hand wheel; *B* is a hollow spindle containing a spring which throws the contact arm to its "off" position when the motor switch is opened; *C* is an electromagnet which holds the spindle and contact arm in any given position as long as current is on the motor; *D, D* are two crowns of contact points by which resistances are cut in or out by the contact arm, *F*.



MOTOR STARTING BOX.

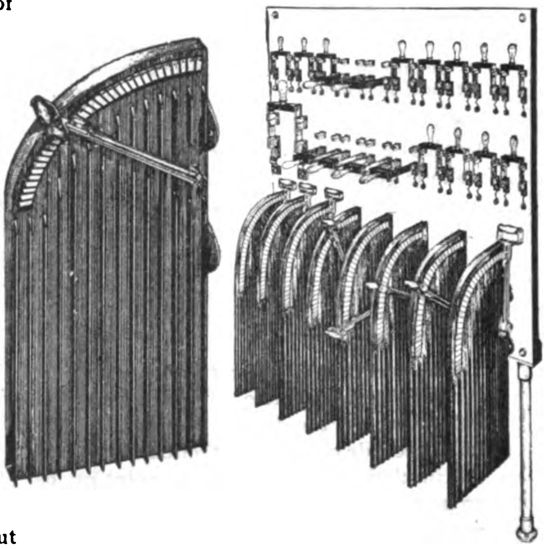
8000-AMPERE CIRCUIT BREAKER.

The large automatic circuit breaker illustrated herewith is designed to break a circuit of 8000 amperes and is to be used on a 160-volt circuit, although made to handle the same current at 600 or 700 volts. This is known as Form K circuit breaker and differs only in size from the well-known K instruments used by the General Electric Company on its standard railway generator and feeder panels. The studs which carry the current are 3¼ ins. in diameter, and the base is 28 ins. square. It is constructed to open the circuit automatically at any point between 3000 and 20,000 amperes, the opening point being arranged by the adjustment of a tension spring on the armature. This circuit breaker, which was made by the General Electric Company, is said to be the largest ever constructed.


LARGE CIRCUIT BREAKER.

THEATRE DIMMERS.

The type of theatre dimmer or rheostat illustrated herewith is particularly designed for the limited space in the wings of a theatre, the entire apparatus taking up scarcely more room than the switch alone of old types. Fig. 1 shows a single section of a dimmer, and the manner in which the sections are mounted on a switchboard is illustrated in Fig. 2. In this type the resistance is disposed in no less than thirty-three sections, thus enabling any desired intensity of light to be obtained.


FIGS. 1 AND 2.—THEATRE DIMMERS.

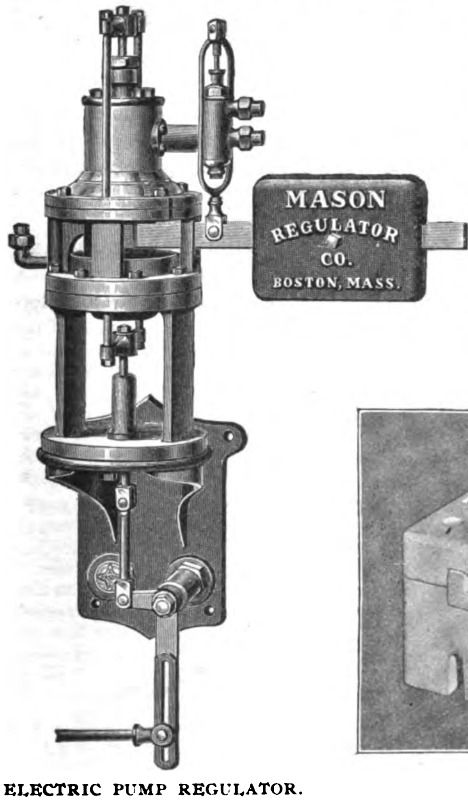
These dimmers are made entirely of cast iron, inside of which, hermetically embedded and sealed in a solid insulating material are the resistance wires. The wires are disposed that, while thoroughly insulated from the iron shell, they are yet in the closest possible juxtaposition to its surface.

The iron shell acts as a radiator, thus rapidly dissipating the heat caused by the electric current passing through the wires. The throw of the switch is so proportioned that where several sections are installed, any or all may be thrown in or out simultaneously. Large dimmers are made up of two or more sections bolted together and connected in series, the terminals of the steps being brought to the contacts on the face plate.

The above type of dimmer is made by the Iron Clad Rheostat Company, Westfield, N. J., and is constructed in all sizes and for any desired combination. This company also builds special dimmers equipped with interlocking switches so arranged that any or all of the dimmers can be thrown in circuit by the movement of one central lever.

ELECTRIC PUMP REGULATOR.

The regulator shown herewith has been designed to automatically govern a pump operating hydraulic elevators. As the pressure of water rises or falls, a small double-acting auxiliary water valve is operated, which admits or exhausts the water from the main operating cylinder, thereby elevating or depressing a bell crank arm. The latter is connected with a switch arm controlling the passage of current to the pump electric motor, thus starting or stopping the pump as often as the air rises above or falls below the desired point.



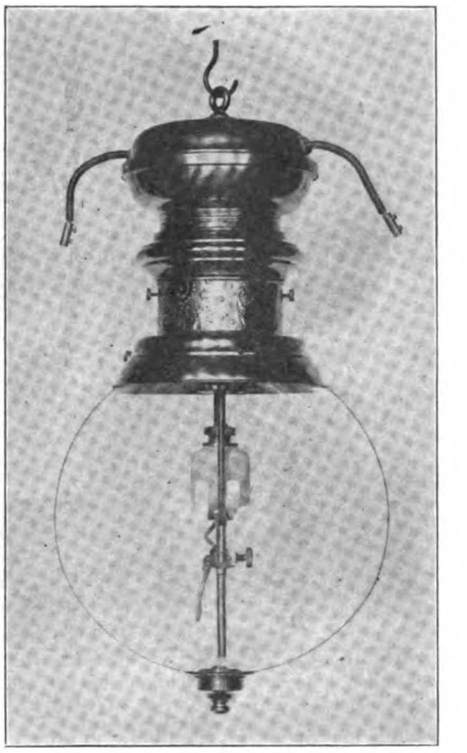
ELECTRIC PUMP REGULATOR.

The above "Mason Rheostat Regulator," is manufactured by the Mason Regulator Company, 6 Oliver Street, Boston, Mass.

CONSTANT POTENTIAL, 100-HOUR ARC LAMP.

The accompanying illustration shows a new 100-hour, constant potential arc lamp, the principal feature of which is its extreme simplicity of mechanism. Though a focus lamp, there is but one wheel in the mechanism, and the entire length is but twenty-four inches over all, thus making a compact artistic type, satisfying the present demand for a small, long service arc lamp.

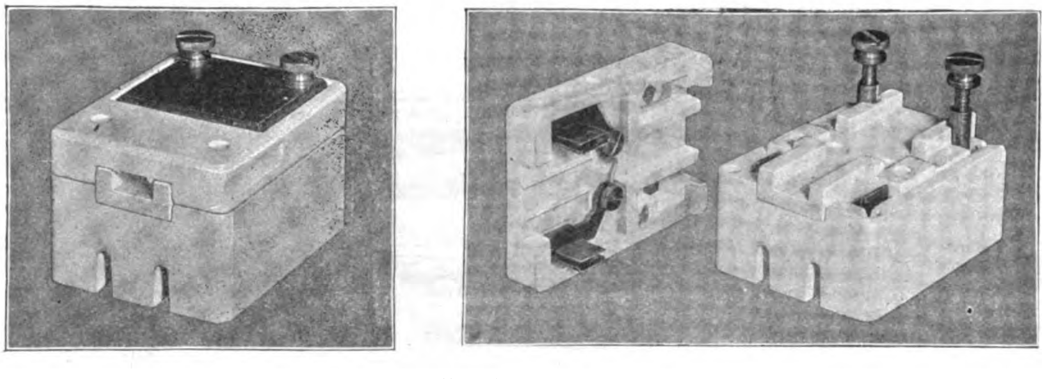
The focusing feature involves a much smaller vacuum bulb, thereby securing a more perfect vacuum without depending so much on the joints at the inclosing device as in a fixed arc. This feature of a permanent center of light will be appreciated by any one having had experience with arc lamps.



100-HOUR ARC LAMP.

The upper and lower carbons are each held flexibly and guided through lava bushings, making it impossible for the carbons to slide past one another and reducing the trouble in trimming down to a minimum. The vacuum bulb is readily removed from the cross-heads by simply lifting it up.

The feed is accomplished by a simple positive device engaging the periphery of the one wheel in the mechanism, and is actuated by a single solenoid. The insulation used in the lamp is lava throughout. The lamp consumes 3½ amperes at 110 volts.

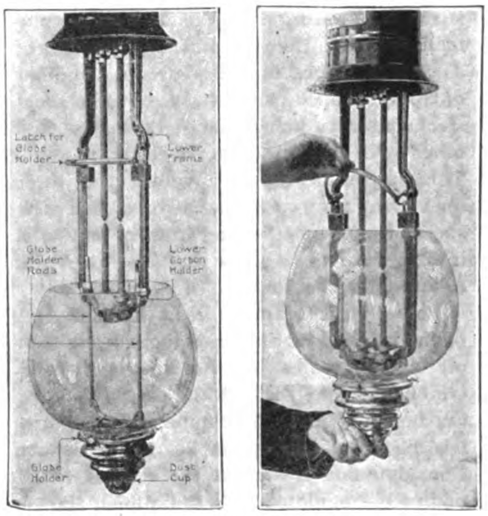


CUT-OUT BOX.

The manufacturers are the Adams & Westlake Company, 127 Ontario Street, Chicago, Ill.

GLOBE LOWERING DEVICE.

The globe lowering apparatus shown in the accompanying illustration has been designed to satisfy the need for a device to lower an arc lamp globe in the shortest possible time without danger of breakage. The holder proper is hung from the vertical rods sliding along the sides of the lower frame. When in normal position, these are held from above by a latch positive and certain in action, and locked by the weight of the rods and holder. To lower the globe, it is first lifted slightly to unlock the latch, which may then be raised, thus releasing the rods and permitting the globe to be lowered several inches farther than in the old style lamps. This gives better access for trimming and cleaning. The fact that the globe must be lifted slightly before lowering insures a support from below and prevents its dropping accidentally. Every arc lamp of the many forms manufactured by the General Electric Company is now equipped with the above new globe lowering device, which is made by the same company.



ARC GLOBE LOWERING DEVICE.

CUT-OUT BOX.

The magnetic blow-out principle used with street car controllers, automatic circuit breakers and lightning arresters, has been recently applied by the General Electric Company to smaller currents. The cut-out box illustrated herewith is designed for the protection of direct-current generators and other apparatus against the destructive effects of overloaded and short circuits, provided the current does not exceed 600 volts and 100 amperes. It may be fitted with fuses of any capacity from 3 amperes to 100 amperes, and any arc which may occur is instantly extinguished. Under test this cut-out box is said to have handled a short circuit of 2000 amperes at 500 volts, extinguishing the arc instantaneously.

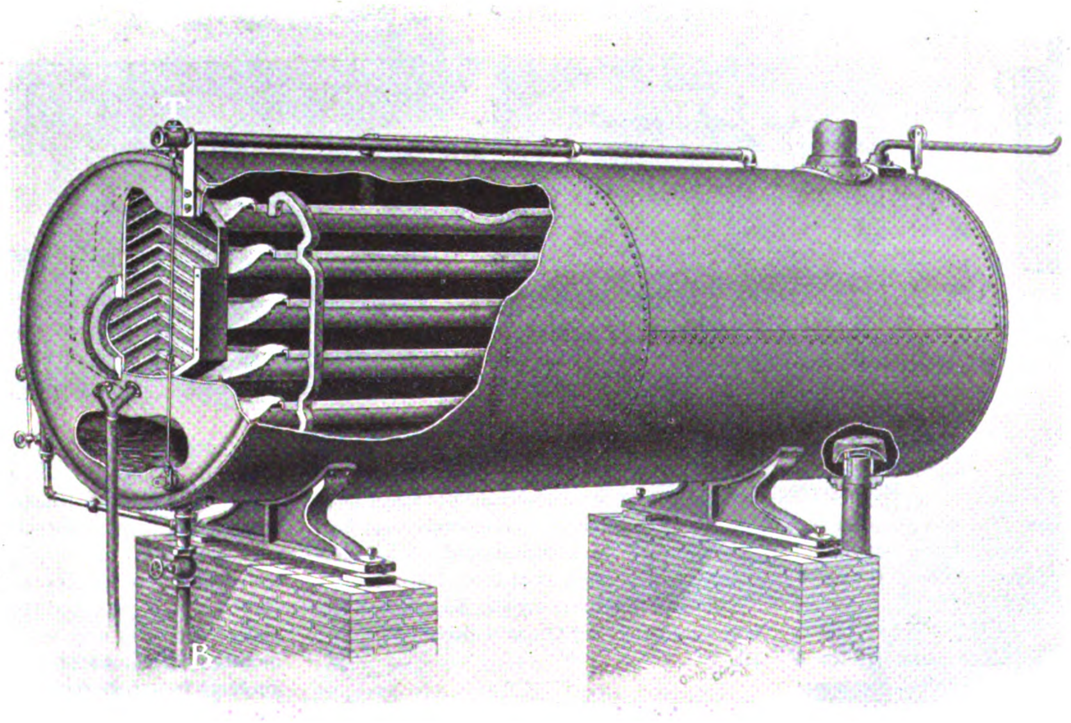
The box is of porcelain, 5¾ ins. × 4½ ins. × 4 ins. thick. The fuse is secured in the cover, and when the cover is in position rests in a closed cavity. The base of the box contains a small electromagnet in circuit with the fuse, and having its magnetic circuit continued in the iron plate on the cover and by the iron screw posts. The magnetic lines are thus compelled to pass across the space containing the fuse, thus maintaining a strong magnetic field at the fuse when the current is flowing. At the blowing of the fuse, the arc which starts finds itself in a powerful field and is immediately extinguished.

FEED-WATER HEATER.

In design, the exhaust steam feed-water heater shown in the accompanying illustration resembles the well-known Hoppes live steam feed-water purifier, made by the same manufacturer. Like the purifier, it consists of a cylindrical shell of steel plate and a number of trough-shaped pans or trays of thin sheet steel, the trays being placed one above the other and supported on steel angle-ways. The top pan has the least width, the lower ones increasing progressively so that the sheet of water overflowing from a pan falls into the one next below it. The pans are easily removable for cleaning.

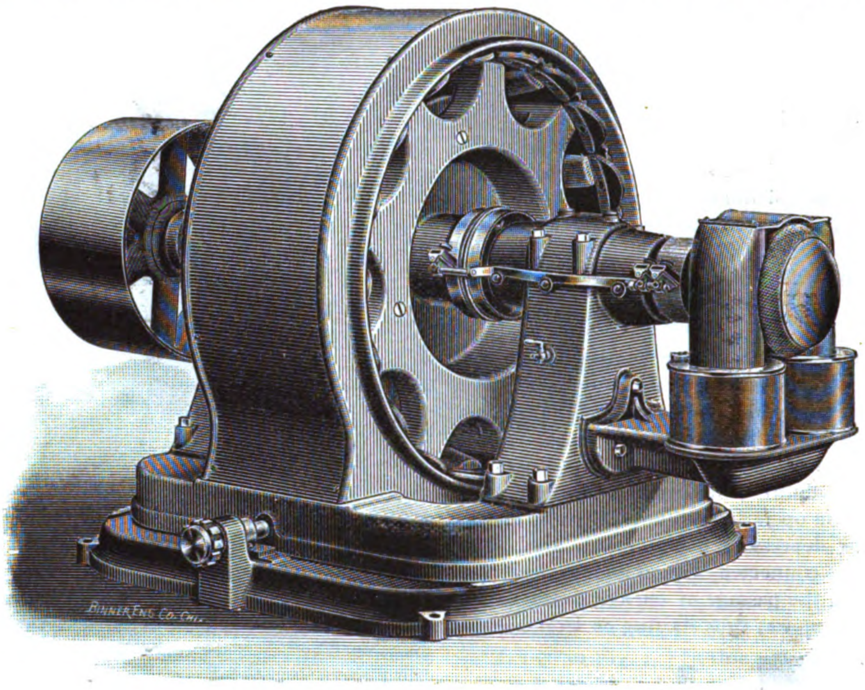
The exhaust steam enters at the back end of the heater, and after passing through an oil catcher, enters the heater proper, from which it escapes through the pipe, *O*, shown at the front end. The pipe, *W*, is a drip leading from the oil-catcher to the sewer. The admission of water to the heater is automatically regulated by a drain float, shown underneath the oil-catcher, which operates the balanced valve at *T*. The water on entering the heater, falls into the top pan first, and flows downward over each pan to the chamber at the bottom of the shell, whence it passes to the pump through the pipe, *P*. While in operation, the pans are full of water and are completely surrounded by the exhaust steam in the shell. Owing to the convex shape of the bottom of the pans, the water is caused to flow in a thin film along the under sides in such a manner that the exhaust steam always comes in direct contact, thus heating the water to the highest degree obtainable without back pressure. The pans afford ample settling chambers for the mud and solids in suspension; the lime and other solids in solution form, as fast as liberated, into scale on the under side of the pans.

No filter is required with this heater, as it removes all the solids from the feed-water which are liberated at or under the temperature of exhaust steam. As the water flows along the under side of the pans, the water always comes in direct contact with the steam, so that it does not matter how much scale may be formed there; the highest degree of efficiency is thus maintained up to the time the heater is ready for cleaning. The exhaust steam being free from oil on entering the heater, that portion of it which is condensed is perfectly pure, and is pumped into the boiler with the feed at saving of some sixteen per cent. of water.



FEED-WATER HEATER.

The Hoppes feed-water heater above described, is made by the Hoppes Manufacturing Company, Springfield, O.


BINNER ENG CO. CHI.

MAYO ALTERNATOR.

COMBINED ALTERNATING CURRENT DYNAMO AND EXCITER.

The rapidly growing importance of alternating current machines has caused renewed attention to be directed to their design, which has recently resulted in several new types of dynamos, one of which is illustrated herewith. In the combined alternator and exciter shown, some of the main features are that the armature is stationary, and thus any armature coil may be taken out and replaced in a very short time without using special tools or disturbing any other part of the machine. The rotating field has only one coil of wire, which takes such a small amount of current at a very low voltage that the chance for a burn-out is reduced to a minimum. The regulation is stated by the manufacturers to be very close and the commercial efficiency high, that of the 60-KW machine being ninety-four per cent. Particular pains are given to the workmanship, and the style and finish of the machine are of the best.

The combination was designed by Virginus J. Mayo, and the machines are manufactured at the Excelsior Iron Works, 100 N. Clinton Street, Chicago, under his supervision.

PERSONAL.

Mr. Elmer A. Sperry, well known from his pioneer connection with the electric lighting industry, and more recently from his electric railway work has been elected president of the Civil Engineers' Club, of Cleveland, O.

Mr E. J. Wessels, general manager of The Standard Air-Brake Company, returned from Europe by the "Paris" on Aug. 8. Mr. Wessels reports largely increased business in sight in Standard air-brakes on the Continent.

Mr. Allen R. Foote, formerly secretary of the National Electric Light Association, later in charge of the electrical department of the 1890 census, and at present editor of the *American Exporter's Journal*, has offered himself as a candidate on the Repulican ticket for election to Congress from the Eleventh Congressional District of the city of New York.

Mr. John W. Lieb, Jr., has been appointed general manager of the Edison Electric Illuminating Company of, New York. Mr. Lieb was formerly in charge of, the Milan (Italy) Edison station, which was erected under his supervision, and was the first large central station in Europe. At the recent annual meeting of the American Institute of Electrical Engineers, Mr. Lieb was elected a manager of that body.

Thos. R. Mercein, secretary of the Northwestern Electrical Association, which held its convention at Marinette last month, looked after the affairs of the association in a most creditable manner. A paper read by Mr. Mercein at the convention, giving an account of an official visit to the East during the National Electrical Exhibition, showed that he possesses not only literary skill but a fine vein of humor.

OBITUARY.

Mr. John N. Gamewell died at Hackensack, N. J., on July 19. Mr. Gamewell was well known throughout the United States from his connection with the development of the electric fire-alarm telegraph, the system which bears his name being used in almost every city and town in the United States.

Mr. Abraham L. Bogart, one of the oldest and best known electricians in the United States, died at his residence in Jamaica, L. I., July 25, at the age of eighty years. Mr. Bogart was the founder of the firm of A. L. Bogart & Company, New York, and both as an inventor and business man, was a principal factor in the development of the electric gas lighting industry in this country.

Mr. John J. Hogan, the inventor of the Hogan boiler, died last month at Middletown, N. Y. Mr. Hogan was born in Ireland and educated in Dublin and Belgium. Recognizing his remarkable mechanical genius, Sir Wm. Fairchild apprenticed him to an English iron works, himself paying the necessary fee of £300. As editor of an advertising periodical issued by his company, Mr. Hogan showed himself to be a technical writer of fine ability, his paper, though professedly an advertising publication, having also an enviable standing as an authority on steam engineering.

NEW BOOKS.

PRESS WORKING OF METALS. By Oberlin Smith, New York: John Wiley & Sons. 276 pages, 438 illustrations. Price, $3.00.

The author of this work is so thoroughly identified with the industry of which it treats, that the book can safely b accepted as authoritative. The subject is exhaustively treated under all of its various heads; the different forms of presses in use are described and illustrated and the various processes of cutting, bending, curling, seaming,drawing, coining, etc., explained, detail sketches being plentifully used where necessary to make the subject more easily followed.

A TREATISE ON THE MEASUREMENT OF ELECTRICAL RESISTANCE. By William Arthur Rice. New York: The Macmillan Company. 199 pages, 70 illustrations. Price, $3.50.

As a systematic account of the methods and processes employed in the exact measurement of resistances, and of the various forms of instruments employed for this purpose, the present work will be welcomed in the laboratory, and by those who have to do with electrical measurements of precision. The chapters on the materials used in the construction of standards of resistance, on the construction of spools or bobbins, on the winding of coils, and on commutators, switches and connections, contain much valuable practical information not easily attainable elsewhere.

ELECTRIC LIGHTING SPECIFICATIONS FOR THE USE OF ENGINEERS AND ARCHITECTS. By E. A. Merrill. New York: The W. J. Johnston Company. 213 pages. Price, $1.50.

The second edition of this valuable book has been entirely rewritten and revised, being brought up to the very latest practice. To those having to write electric lighting specifications, this volume is indispensable, as it not only reduces labor to a minimum, but insures that every point of importance is included in a specification. The plan of the work is such that by its aid specifications for a plant of any size may be rapidly drawn up, the marginal references to subjects enabling those applying in any given case to be found at a glance.

ELECTRIC INCANDESCENT LIGHTING. By Edwin T. Houston, Ph. D., and A. E. Kennelly, Sc. D. New York: The W. J. Johnston Company. 449 pages, 146 illustrations. Price, $1.00.

This is the sixth volume of the "Electro-Technical Series," and has been prepared with the view to presenting both the art and science of practical electric incandescent lighting to the general public in such a manner as to render the subject capable of being understood without any previous technical training. The information contained is, however, so complete that the book will be found of value to every electrician who has not had the advantages of extended experience or study. The twenty chapters treat of every branch of the subject, inclliding the physics and manufacture of the incandescent lamp, meters, storage batteries, series incandescent lighting, etc.

TRADE PUBLICATIONS.

The Chicago General Fixture Company's new catalogue, No. 22, devoted exclusively to electrical supplies, and book No. 23 to fixtures, will be ready for distribution Aug. 25.

Recording Electrical Instruments. The Bristol Company, Waterbury, Conn., in a recent catalogue describes and illustrates the Bristol recording voltmeter, ammeter and wattmeter, giving fac-similes of records. Unlike most recording instruments, the price of these is very moderate, thus placing them within reach of smaller installations.

Power Pumps. Rumsey & Company, 35 Dey Street, New York, have issued a new catalogue descriptive of the numerous forms of hydraulic pumps manufactured at its works at Seneca Falls, N. Y. Among the types illustrated is a triplex power pump driven by an electric motor. A chapter on hydraulic rams and their setting very clearly explains the principles and working of this interesting form of hydraulic apparatus.

Corliss Engines. In a large page, cloth bound and handsomely printed catalogue, the Watts-Campbell Company, Newark, N. J., in addition to descriptions of the engines of its manufacture, touches upon a number of matters in steam engineering of general interest. The various parts of the Corliss engine are illustrated by clearly drawn and well engraved cuts, and the information given in regard to foundations, engine running, etc., will be of value to everyone having to do with the steam engine.

The Newton Machine Works, Vine and Twenty-fourth Streets, Philadelphia, describe and illustrate in a recently published pamphlet a new boring, drilling and milling machine. This machine, unlike most combined tools, is not at all complicated—the engraving showing it to be of an unusually graceful mechanical appearance. The front part of the machine is like an ordinary commercial horizontal boring and drilling machine, while the rear is of a new and improved design.

High Speed Engines. The Watertown Steam Engine Company, Watertown, N. Y., in a recent catalogue shows a number of types of the Watertown high speed engines. The illustrations are full page in size, printed on a tinted background and enclosed by a border of a neutral tint—the effect being very pleasing. The text is concise and to the point, bringing out the features desirable in a high speed engine and shows how these are embodied in the Watertown design.

The Hawley Down-Draft. In a large and handsomely bound octavo catalogue of no less than 206 pages, the Hawley Down-Draft Furnace Company, Chicago, gives an account of its fuel-saving and smoke-consuming furnace, with illustrations of several hundred office buildings and manufactories in which the furnace is used. The technical account of the furnace is very clearly written, one of the features being engravings showing the manner of its attachment to all the better known boilers on the market.

Raymond Gas Engine. The J. I. Case Threshing Machine Company, Racine, Wis., in its catalogue of the Raymond improved gas engine has been guided by what seems to be a policy on the part of engine makers to spare no care or expense in getting out descriptive literature relating to their manufactures. In the present instance the result is very satisfactory from both the artistic and trade standpoint. The various types of Raymond gas engine are illustrated by beautifully engraved woodcuts, while the text displays the height of the typographer's art, and the embossed covers are in keeping.

BUSINESS NOTES.

The Iron Clad Rheostat Company has just completed an addition to its works at Westfield, N. J.

The Anchor Electric Company, Boston, was well represented at the Marinette convention of the Northwestern Association by Mr. C. O. Baker. Mr. Baker, as usual, made many friends.

Jos. M. Hill, general sales agent of the Wagner Electric Manufacturing Company, St. Louis and Chicago, manager of the Columbia Incandescent Lamp Company, St. Louis, was present at the Northwestern convention at Marinette last month.

George Cutter, of Chicago, was in attendance at the Northwestern convention last month and while there added to his reputation as a clear-headed speaker on technical subjects, and made a decided hit as a post-prandial orator.

The Ohio Electric Works, Cleveland, O., is meeting with much success with its bicycle electric lamp. The lamp gives a light for four hours on one charge, and all who have seen it at work agree that electricity is the proper thing to use for a light on a wheel.

The Electrical Exchange, of Chicago, recently sold the Merrill Railway & Lighting Company, Merrill, Wis.,a 60-KW, 500-volt Edison generator and three car bodies fitted with W. P.-30. T.-H. motors and trucks. The Merrill Company's plant was recently destroyed by fire.

The St. Louis Electrical Supply Company, St. Louis, Mo., has just increased its capital stock to $45,000, being an increase of $15,000 over its former capital. Mr. Russell Stanhope comes in as a director. This increase of facilities will enable the company to extend its business and carry a larger stock.

The Hawley Down-Draft Furnace installed in the New York Custom House is reported by Chief Engineer Joseph Kenney to be giving excellent satisfaction. Though soft coal is used in the fire room, no smoke comes from the chimney, except a slight puff when a furnace is being fired.

The Central Electric Company, Chicago, had in attendance at the convention of the Northwestern Electrical Association Mr. H. D. Latimer, who has represented the Central Electric Company for a long time. As an expert in many lines, the opinion of Mr. Latimer was much in demand by the delegates.

The General Electric Company had in attendance at the recent cenvention of the Northwestern Electrical Association at Marinette, Messrs. A. C. Bunce, F. N. Boyer and P. A. Clisdell. Mr. Bunce, by the way, is a brother of Rear Admiral Bunce, U. S. Navy, now flag officer of the White Squadron.

The Electric Appliance Company, Chicago, had its interests well taken care of at the recent Northwestern convention, by its president, Mr. Willard W. Low. Mr. Low distributed some excellent literature among those in attendance, in addition to having a pleasant time with the delegates and other visitors to the convention.

Union Carbon Battery. The demand for the Union carbon battery, manufactured by C. M. Turnquist, 216 S. Clark Street, Chicago, Ill., is rapidly increasing. This battery is especially appreciated by telephone men and electric bell-hangers. It is claimed that this battery is stronger, and lasts longer than any other carbon battery on the market.

The W. H. Sills Mica Company, 59 Lake Street, Chicago, has purchased the business lately conducted by W. H. Sills & Co., and under the new name the extensive mica business done by the old firm will be carried on. The new company will extend its facilities and be fully prepared to fill orders as miners, importers and dealers in mica of all kinds and grades.

M. R. Rodrigues, 17 Whipple Street, Brooklyn, will shortly place on the market a new model of the Grenet battery. This cell is especially intended for experimenters and will be sold at a low price. The jar will be 2½ ins. square and 4½ ins. deep, with a cover made in such a way that it also serves to hold the two carbon plates, the zinc being suspended in the center and easily removable.

The Chicago Rawhide Manufacturing Company, 75 and 77 E. Ohio Street, Chicago, has recently been sending out some handy blotters, on which is printed an advertisement calling attention to the rawhide bell and register cord which the company makes a specialty of manufacturing. It is claimed by the manufacturers that this bell cord is tougher, stronger and lasts longer than bell cord made of other materials.

Chas. A. Schieren & Company, 45 Ferry Street, New York, manufacturers of leather belting, have just received an order from the Stamford Gas & Electric Company, for about 115 ft. of fifty-inch double belting. Also an order from the American Sugar Refining Company, for 108 ft. of fifty-eight inch three-ply belting. The demand for belting from this firm is very considerable, notwithstanding the depressed condition of trade.

The New York Insulated Wire Company had in attendance at the recent Northwestern convention in Marinette, its Western manager, Mr. Jas. Wolff. Mr. Wolff, as usual, made many additions to his host of friends and looked after the interests of his company in the best possible manner. The New York Insulated Wire Company is to be congratulated upon having as its representative one of the most popular men in the entire West.

The President of the People's Electric Company, of Madison, Wis., was in attendance at the Northwestern Electrical convention last month. The exhibits were limited in number, but Mr. Burch had with him an automatic limit switch as well as some other specialties, including a switchboard made by the Standard Telephone Company, of the same city. Mr. Burch is an example of the many college educated men who are winning success in the commercial electrical field.

The Rankin & Fritsch Foundry Machine Company, St. Louis, has just shipped two 1500-HP engines to the Milwaukee plant of the Illinois Steel Company. These engines weighed 240,000 lbs. each, and it required two special trains of eight cars each to carry them to their destination. The company has just installed for the Union Depot Railroad Company, of St. Louis, a 22 in. × 42 in. Corliss engine running at 125 revolutions. This machine is direct connected to a General Electric dynamo.

The Fort Wayne Electric Corporation, Fort Wayne, Ind., had in attendance at the convention of the Northwestern Electrical Association last month Messrs. C. E. Wilson and W. J. Buckley, Chicago. It is needless to say that the company's interests were well taken care of. Mr. Buckley, judging from the appreciative manner in which an address he delivered before the convention on high efficiency lamps was received, stands high in the estimation of the members as an electrical authority.

The H. Channon Company, Chicago, sends information that the Ajax brand of rope which it has been introducing in electric lighting and railway plants, is taking splendidly wherever put in. The company especially recommends this brand of rope for power transmission in large electric lighting and railway plants. The company recently brought out a treatise on rope transmission which is very complete and valuable to anyone interested in the subject. A copy of this is sent free to anyone who asks for it and mentions AMERICAN ELECTRICIAN.

Lounsbury & Company, Chicago, have just taken the Chicago agency for the engines made by the Racine Hardware Manufacturing Company. These engines are well known, a large number having been installed. The firm is putting in a number of plants direct connected to the dynamo which it makes and which is especially adapted to this service owing to the extremely slow speed. Messrs. Lounsbury & Company, report a good number of inquiries for dynamos and motors. The electric hoists, a description of which appeared recently in this paper, is also attracting wide attention.

The C. & C. Electric Company has started the manufacture of alternating current generators at its works at Garwood, N. J., and will soon have ready for delivery 25-KW and 50-KW sizes. 100-KW and 400-KW sizes will be placed on the market during the winter and spring. The apparatus will be of the inductor type, and alternating current motors will also be manufactured. Another branch of manufacturing, to be taken up in the near future by this company, is that of switchboards, and in time other apparatus, the intention of the company being to engage in general electric manufacturing.

Birkholz & Company, 42 Cortlandt Street, New York, have commenced the manufacture of a gas engine especially adapted for electric lighting, and which promises to definitely supply a long-felt need in this direction. The engine is much more mechanical in appearance than the usual gas engine, having vertical cylinders and occupying but little space. The governing device is remarkably efficient which, united with the fact that there is an explosion every revolution in the smaller types, and one every stroke in the larger engines, results in limiting the speed fluctuation to a percentage as low as in the best types of steam engines.

An Electric Bridge. The new highway bridge across the Connecticut River, connecting Middletown with Portland, Conn., is now swung by electricity. The electrical equipment consists of four G. E. 800 motors. Two of these are connected with the swinging mechanism, one working and the other being held in reserve. Of the other two, one is located under each end of the turning span, to raise it from the fixed piers before the third motor begins to swing it. The bridge span is 450 ft. long, the longest single span highway bridge in the world. Previous to the installation of this electrical equipment by the General Electric Company, fifteen men were required to start the bridge and eight men to swing it.

The Electric Appliance Company, Chicago, was very successful on large deals during the month of July, closing an unusual number of orders for complete electric supply equipments for several good sized plants. It also states that the general volume of business for the month was reasonably satisfactory, considering the time of the year, and the general condition of trade. As general Western agents for "Electra" carbons, the company is meeting with much success in extending the field for this sterling brand of arc light carbons. It has recently remodeled its "American" telephone switchboard, introducing a number of important improvements, which, it is claimed, will make the board the most desirable on the market.

The M. C. Bullock Manufacturing Company, 1170 W. Lake Street, Chicago, has received among recent orders one from Krippendorf, Dittman Company, Cincinnati, for a 120-HP, compound, central valve, non-condensing Willans engine for direct coupling. This is the third central valve engine that has been purchased by this company for its shoe factory, in which both the lighting and power systems have been remodeled in accordance with the most approved practice, using electricity in almost every operation. Mr. Dittman, in company with Mr. Chas. E. Rice, the consulting engineer of the company, made an extended investigation before deciding on the plant finally installed, and the factory is now probably the most complete and up to date in its arrangement and equipment in the West.

The Monash-Younker Company, 203 South Canal Street, Chicago, Ill., has lately been incorporated for the manufacturing of steam and water specialties. The new company owns and controls all the specialties manufactured by the Van Auken Steam Specialty Company, who will continue to manufacture its specialties, the goods being sold through the new Monash-Younker Company. This new company has also purchased the patents and plant of the Star Coupler Company, of St. Louis, Mo., and will manufacture "Star" lead pipe couplers and fittings for lead pipe plumbing without soldering or wiping a joint. Those interested in high grade steam specialties or the new method of doing lead pipe plumbing without soldering or wiping joints should address the Monash-Younker Company for its catalogue and mention this journal.

X-Ray Apparatus. Investigators and others practically interested in X-ray work will without doubt be greatly interested in noting the appearance of a large and responsible concern as manufacturers of all kinds of X-ray apparatus. The Edison Decorative & Miniature Lamp Department (General Electric Co.), Harrison, N. J., is in the field with an entire line of X-ray apparatus of all kinds. The name of this concern alone is sufficient guarantee of the completeness and efficiency of any apparatus that it may put out, having at its command the services of the most thorough experts in the country in its various branches. We hope to be able to present to our readers shortly some further description of the apparatus which is now being made and extensively sold by the above concern.

The Card Electric Motor & Dynamo Company, Cincinnati, O., is equipping the presses of the *Chicago Journal* with three 20-HP direct connected motors, running 200 r. p. m. The new printing and binding plant now being put in by Munsey's Magazine at New London, Conn., is also to be equipped by this company throughout with generators and motors for running thirty presses, cutters, binding machinery, etc. Another interesting installation and quite a novel application of the motor, is the equipment now under way of the U. S. Monitor "Terror" with a reversible motor for operating its steering gear. Besides these new applications, the company is also shipping quite a number of railway motors, among recent shipments being twelve equipments to Georgetown, Ky. On the whole, the company is to be congratulated upon the fact that it is kept constantly busy and obliged to run full time to keep up with orders.

The Commercial Electric Supply Company, St. Louis, is just getting settled in its new quarters at 1007 and 1009 Market Street. The building occupied by the company consists of 16,000 sq. ft. of floor space, there being four floors. The sales rooms and sales offices are located on the first floor; it is somewhat of an innovation in the supply business to devote an entire first floor to sample rooms, which in this instance will contain show cases in which it is aimed to keep everything in the supply line. The only office on this floor is that devoted to the sales. On the second floor are located the general offices, including book-keepers, private offices of the officials, together with the shipping department. All orders are filled on this floor. Small wires, conduits, etc., are kept in stock on this floor. The third floor is devoted to a general stock room and contains bins and shelves for everything. The basement is devoted to heavy material, wires, cross arms, etc. The company has now every facility for the transaction of its business, the building being in every way arranged with reference to convenience This company has a very large and growing business in the South and Southwest, as well as in all other parts of the country. Mr. Jos. Franklin, Jr., is the president of the company, and Mr. J. Franklin, Sr., is the secretary and treasurer.

American Electrician.

Vol. VIII. New York, September, 1896. No. 5.

ELECTROLYTIC COPPER AND SILVER REFINING.

FEW electricians are aware of the vast proportions which the industry of the electro-deposition of metals has assumed within the past few years. In 1894, 57,500 tons of copper, or almost one third of the entire copper output of the United States, was electrolytically refined; since then there has been a large increase, and at the present time not far from one-half of all the copper produced in this country is refined in the electrolytic bath.

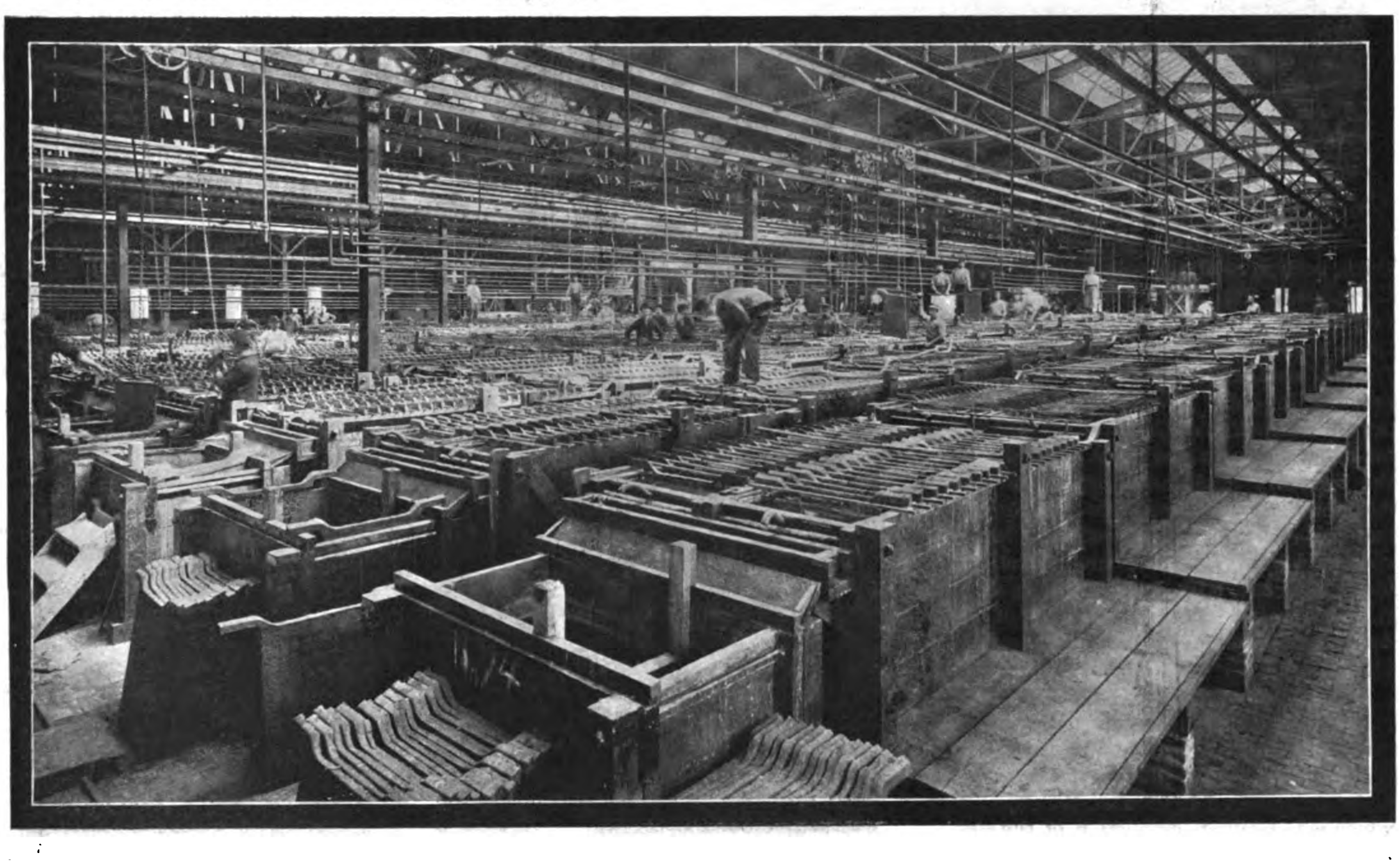


FIG. 1.—COPPER DEPOSITING TANKS.

One of the latest electrolytic refining plants erected in this country is that of the Guggenheim Smelting Company, at Perth Amboy, N. J., which has an annual capacity for about 10,000 tons of copper and 30,000 oz. of silver, and is equipped for the most modern processes of refining. The copper here refined carries a large percentage of gold and silver, and the silver parting plant also handles the precious metals separated from a rich lead bullion that undergoes a final heat metallurgical process at these works. The refinery is in operation 365 days in the year.

The copper is received at the works in bars, having already undergone the process of raw smelting from the ore and concentration from the resulting matte. At the works the metal is again heated in reverberatory furnaces and then cast into anodes for the electrolytic bath. Before commencing a description of the final or electrolytic process, the electrical generating plant will be considered.

Electrical Generating Plant.—The boiler plant consists of five Babcock & Wilcox boilers rated at 125 HP each, and generating steam at 150 lbs. pressure. The dynamo generating plant consists of two systems—one supplying current for the commercial copper depositing baths, and another for the electrolytic manufacture of cathode plates whose object will be explained later.

The commercial plant consists of two Porter-Allen triple-expansion condensing engines, running at 250 r. p. m. and driving two General Electric generators, the commutator end of one of which is shown in Fig. 2. The generators are of the eight-pole multipolar type, each of a capacity of 180 KW, and delivering 1500 amperes at 120 volts; they are shunt wound with smooth core armatures of the ring type.

With generators for this service, the matter of brushes is an important one. In the present instance good satisfaction is being given by woven-wire brushes, of which there are three to each brush-holder, or twenty-four in all, the cross section of each brush being 7/16 in. × 1 13/16 ins. The switchboard of the commercial plant is shown in Fig. 2.

The cathode system is supplied by a General Electric generator, shown in motion in Fig. 3, specially designed for the plant. It is a four-pole machine with a capacity of 12 KW, and delivers 1000 amperes at 12 volts; the field is separately excited from a 110-volt power circuit. The commutator is twenty-four inches in length, fourteen inches in diameter and contains forty segments, each 1 1/16 ins. wide. The brushes, sixty-four in number, are of carbon containing a copper wire core; the cross section of the brushes is 1¼ ins. square. The cathode generator is driven by a Standard 25-HP Westinghouse engine.

In addition to the electrolytic dynamos there are two four-pole 40-KW power generators and one 40-KW 110-volt incandescent lighting generator. A considerable number of electric motors are employed for various purposes, their power ranging from 50 to 7½ HP. Two Otis freight elevators, a Shaw crane, and desilverizing kettle stirrers are operated by electric power.

The Cathode Baths.—In the system used at the Guggenheim refinery, the copper is deposited on special cathode plates, which plates are prepared in a system of tanks separate from the commercial tanks. Rolled copper sheets 1/10 in. thick, receive the cathode deposit, which is permitted to become 1/25 in. thick, both sides of the rolled copper being thus plated. Fig. 4 shows the rolled plates prepared for the bath. Wood strips form a frame about three sides of the plates; after the two surfaces are oiled and covered with graphite in order to prevent the cathode deposit from sticking, the plates are placed in tanks between commercial anodes and after the necessary thickness of copper is deposited, the shells are stripped from the plates and are ready for use as cathodes in the commercial tanks. There are 30 cathode tanks, each 8 ft. 6 ins. long, 3 ft. deep and 2 ft. 6 ins. wide. The cross-section of the conductors supplying current to the tanks is 1¼ ins. square.

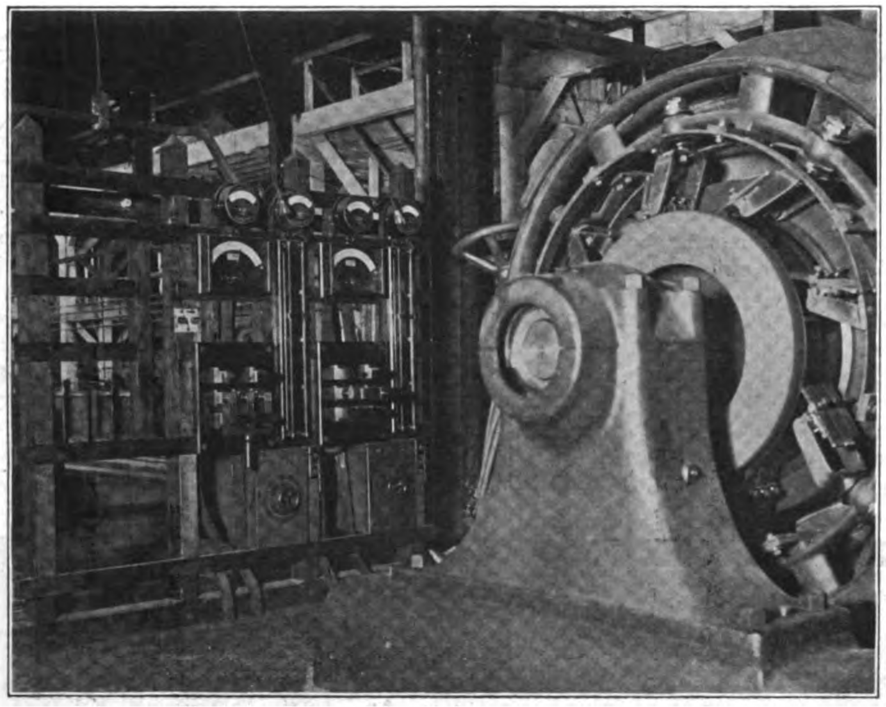


FIG. 2.—GENERATOR OF COMMERCIAL SYSTEM.

The Commercial Baths.—Fig. 1 gives a general view of the tanks for the commercial deposition of copper, and a single tank is shown in Fig. 5. As will be seen, the tanks are arranged in terraces, the object of which is to facilitate circulation of the electrolyte. There is a difference of level of about two inches between each row of tanks, and an overflow pipe of the necessary diameter keeps up a sufficient circulation to maintain the electrolyte in proper condition—there being a constant supply of new fluid to replace that drawn off. The tanks, which number 360 in all, are of 2-in. pitch pine coated with "P. & B." paint, each being 9 ft. 10 ins. long, 3 ft. deep and 2 ft. 6 ins. wide. The electrolyte as prepared for the bath, has in solution, by weight, 16 per cent of bluestone and 5 per cent of free sulphuric acid. Samples from the tanks are frequently tested in order to insure reliability of result.

Each tank contains twenty-two anodes and twenty-three cathodes. The anodes for electro-deposition are cast in the shape shown in Fig. 6. They are 2 ft. 6 ins. long, 2 ft. wide, 3 ft. 2 ins. across the lugs, and 1¼ ins. thick.

All of the 360 tanks are in series, and the plates of each tank are in multiple. On the outer side of each tank is a copper bar 1¼ ins. square in cross-section, and on the inner a wooden bar which together form the supports for the anodes and cathodes; the two outer bars of each pair of tanks are the + and — conductors. The tops of the cathodes are bent as in Fig. 4 and hang from copper cross bars, while the anodes are supported by their lugs (Fig. 6).

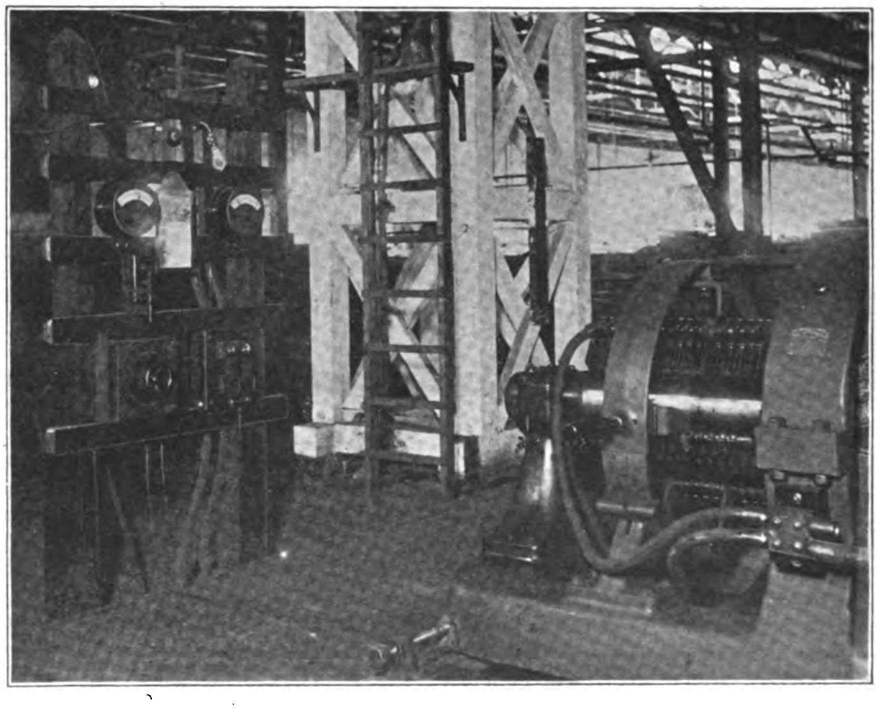


FIG. 3.—GENERATOR OF CATHODE SYSTEM.

The tanks are arranged in pairs, as shown in Fig. 7. *M*, *M*, *M*, *M*, are the ends of tanks, the supporting and conducting bars above referred to being represented by the heavy horizontal lines. The heavy vertical lines represent the anodes, and the lighter vertical lines the cathodes. The small circles under one end of each cathode and anode is a square porcelain insulating block, the object of which will be apparent from the next paragraph.

Referring to Fig. 7, current enters the lower tank to the left through its twenty-two anodes in multiple, of which one, *A*, is shown; the cathodes, it will be seen, are insulated from the positive conductor. The current then proceeds through the bath to the adjacent cathodes, *B*, *B*, and then, by means of the connectors, *C*, passes to the anodes of the second bath; then continuing through this bath, it enters the cathodes, *D*, passes to the extreme conductor, and enters the next pair of tanks, in which its course is the same as that just described.

It will thus be seen that the tanks of each pair are in series the same as the adjacent pairs of tanks. In the actual tanks, the connectors, *C*, are plates of copper 6 ins. long, 2½ ins. wide and ⅛ in. thick, supported on the two wood bars, *L* and *L'*; the end of a cathode and anode bar, respectively, resting on each plate.

The anode and cathode plates are separated by about 1¼ ins. The current density is about ten amperes per square foot (counting both sides of the anode plate), and it requires about twenty-four days of twenty-four hours to electrolytically transfer the copper of the anode to the cathode plate, the weight of the former being about 275 lbs. The density of the current varies with the richness of the anode in precious metals; if a large quantity is present, a high density would carry part of the silver to the copper. In very pure copper a density as high as ten and even twenty amperes may be carried. The voltage, of course, depends only upon the ohmic resistance of the electrolyte, conductors and plates. With 356 tanks (four tanks are always out of circuit, having "slime" removed and being otherwise cleaned), the voltmeter at the switchboard registers from 117 to 120 volts with 1500 amperes.

At Perth Amboy the copper refined is usually rich in precious metals, carrying at times 600 oz. of silver and 4 oz. of gold to the ton of copper. If the current is kept at the proper density, all of these metals, together with impurities like bismuth and antimony, are deposited in the bottom of the tanks in the form of a black slime, which name it goes bv in the refinery.

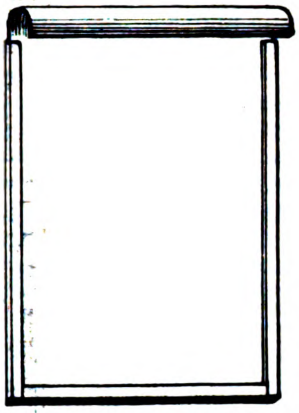


FIG. 4.—CATHODE FORMER.

This slime is carefully gathered and passed through chemical and heat reducing processes, which remove most impurities and concentrate the silver and gold; the latter is then ready for what is known as the electrolytic "parting" process. At the Perth Amboy works, lead carrying silver and gold is also refined, and the precious metals from the lead and the copper are united in one of the final processes of concentration preparatory to electrolytic "parting."

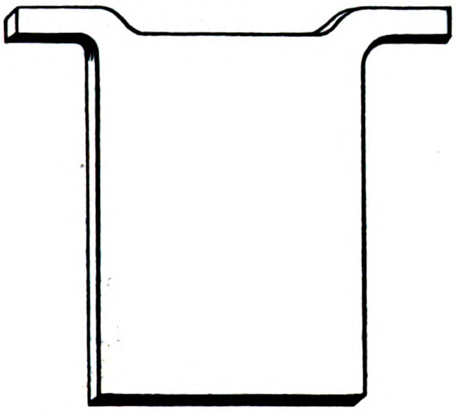


FIG. 6.—ANODE CASTING.

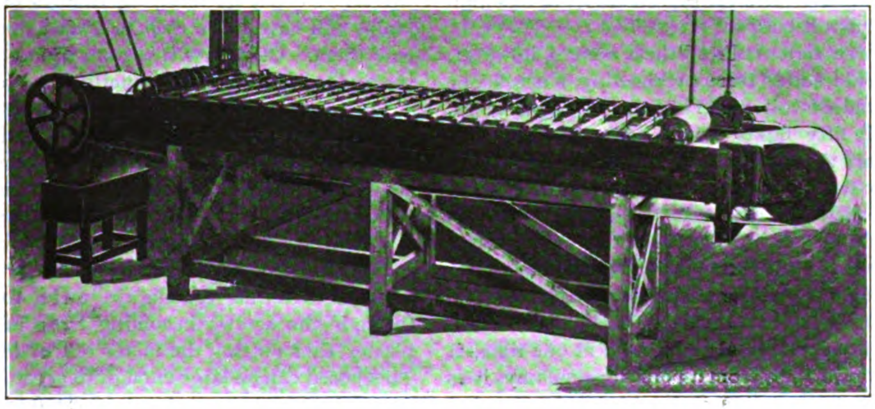


FIG. 8.—SILVER PARTING TANK.

Silver Parting Plant.—The silver refining process used at Perth Amboy is that of Dr. B. Moebius, and is very interesting in its various details. The latest form of depositing tank is shown in Fig. 8, to which the description that follows will apply.

The peculiarity of the Moebius process consists in the employment of a belt for the cathode, which belt is always kept in motion, and from whose surface the silver deposited from the anodes is continuously removed by scrapers located at one end of the tank. The belt, which is clearly shown in Fig. 8, is made of a sheet of pure rolled silver, fifteen inches wide, thirty-one feet long and weighing about forty pounds. Its upper portion passes about ½ in. beneath the lower surface of the anodes; the belt is given a motion of about three feet per minute.

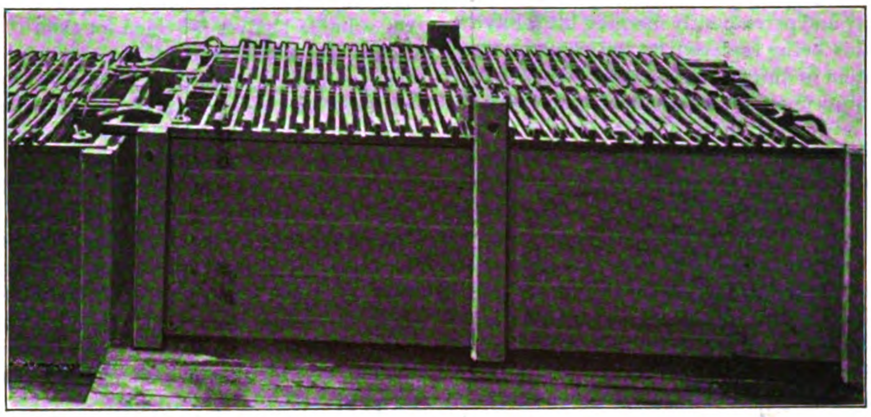


FIG. 5.—TANK OF COMMERCIAL SYSTEM.

There are forty-eight Moebius tanks in the silver parting plant, grouped in eight sets of six tanks each. The tanks, which are made of 2-in. pitch pine coated with acid-proof cement, are 14 ft. 3 ins. long, 16 ins. wide and 7 ins. high, and are arranged in tiers of three.

In each of the latest type of tank there are twenty-four wood frames one inch deep, each of which contains an anode; over the bottom of the frames a muslin diaphragm is stretched, and the anode rests on four hickory cross rods about ½ in. above this; the cathode belt passes about half an inch below the diaphragm. The anodes are 12 ins. long, 3 ins. wide and ½ in. deep, containing usually 100 oz. of silver and from .3 to .8 oz. of gold. The anode contact levers shown in the illustration are tipped with platinum; the cathode contacts are shown to the right of the cut, and consist of silver brushes bearing on the cathode belt. To the left of the tank is a revolving scraper or brush which, as the surface of the belt passes over it, removes the deposited silver and permits it to fall into the hopper shown in the illustration.

The electrolyte consists of nitric acid (38 Baumé) having dissolved in it granulated silver; some nitrate of soda and nitrate of copper are also added when starting up with a new solution.

A General Electric generator supplies 200 amperes of current; the voltage depends upon the strength of the nitrate solution and the length of time the anodes have been in circuit, but averages about ninety volts. All of the forty-eight tanks are in series, and the anodes of each tank are in parallel. The capacity of each tank is 600 to 700 oz. of silver per twenty-four hours.

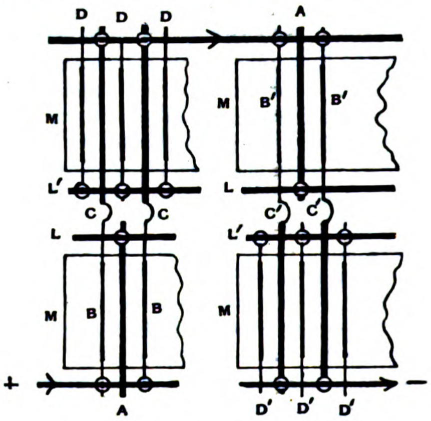


FIG. 7.—TANK CONNECTIONS.

The residue from the anodes is principally deposited on the muslin diaphragms, and consists of gold, bismuth, lead and antimony. The former metal is finally recovered from the residue by chemical means.

Edison Illuminating Companies.

At the seventeenth convention of the Association of the Edison Illuminating Companies, held at Manhattan Beach, Aug. 11-13, the following officers were elected: President, Samuel Insull, Chicago; vice-president, R. R. Bowker, New York; secretary, W. S. Barstow, Brooklyn; treasurer, J. W. Lieb, Jr., New York. Executive Committee: C. L. Edgar, chairman; Alexander Dow, George R. Stetson, A. W. Field, J. H. Vail; the officers of the Association are also members of the Executive Committee. At the conclusion of the meeting the members and guests took a special Pullman train to Schenectady, where they made an inspection of the General Electric Works.

Care and Management of Electric Motor-Meters.

By Thos. Duncan.

In these days of electric incandescent lighting when the flat-rate system is gradually and permanently merging into oblivion, and is being replaced by the common sense system of integrating meters, a few remarks or hints upon the use and management of the latter will not be out of place.

When an electric lighting station is installed, it too frequently happens that the meter is invariably the last instrument or piece of apparatus to be considered and put into active use. This is a mistake, as has been demonstrated in many small plants started in this manner. I say small plants, because it is this class which practices and suffers most from this cause.

If meters were installed from the commencement, there would not be half the complaints received from consumers, as is the case when a change is made from a flat rate to a meter basis—a change which must eventually be made by all producers of electrical energy for distribution and consumption as light and power.

Suppose we take the case of a consumer who is being supplied on a flat-rate basis, and paying sixty cents per month per lamp. If he has five lamps it costs him three dollars. This is on the supposition that he will probably use these five lamps on an average of two hours each evening. If he does, then the price is remuneration enough. The fact is, however, that since he knows that he has to pay three dollars monthly for his five lamps, he is going to use them all he can, and instead of the daily average of burning being two hours it is more likely to be four. In this way, the central station man cannot help but be the loser. Now if he changes over to the meter basis, what is the result? This customer will naturally find that his bill is double what it was on the old basis—that is, provided he uses his lamps in the same manner. He cannot help but enter a complaint for the overcharge, for such it appears to him, and the probability is, he will tell the station man either to give him back the flat-rate or take out his lights.

If the consumer had used his five lights on an average of two hours each evening during the month, or for, say, thirty days, then the change would not have made any apparent difference, because five lights for two hours each day and for thirty days would be equal to $5 \times 2 \times 30 = 300$ or 300 lamp hours; this at one cent per lamp hour is three dollars, or just the amount asked by the lighting company on the flat-rate basis. But suppose he continued to use his five lamps on an average of four hours daily after the meter had been installed, the result at the end of the month would be that the meter read just double or $5 \times 4 \times 30 = 600$ lamp hours; this at one cent per lamp hour would be six dollars, or the actual amount due the lighting company instead of only three dollars as was being paid on the flat-rate basis.

These comparisons are indeed very mild, as I have known many cases where the consumer, without any apparent necessity, burned some of his lamps all night—something that would never be practised with a meter in circuit.

When meters are received from the manufacturer they should not be let stand around in the boxes in which they are packed, but ought to be taken out and inspected. After this they should be placed, until needed, on suitable shelves provided for their reception in the store-room. This not only systemizes matters, but gives the man in charge of the meters an opportunity to see whether they have been received in good order, and if damaged give him an opportunity to notify the proper parties, as it frequently happens that meters are damaged in transit. It is also well to have a few meters of the sizes most used constantly on hand and not wait until they are actually needed before being ordered, as this often results in considerable delay, since the manufacturers are sometimes unable to ship meters immediately upon receipt of order.

If the lamps are wired in and no meter on hand, it is common practice to let the consumer have light free until the meter arrives, which may be for a week and possibly longer. This is very poor management and should be discouraged and abandoned by all central station men. Just imagine a gas company supplying one or more customers with free gas until the meter arrived—a transaction seldom if, in fact, ever heard of.

Before a meter is installed it should be tested to see that it is running all right, and that it is of the proper voltage and carrying capacity for the work and circuit to which it is to be applied; this will materially reduce the losses sometimes incurred in placing, by mistake, fifty-volt meters on one hundred-volt circuits, and installing meters of a carrying capacity much too small for the load. If by accident a one hundred-volt meter is put on a fifty-volt circuit, there is likely to be trouble at the end of the month when the reading of the meter is taken. If it be a lamp-hour meter, the reading will be nearly double what it should be; if it be a wattmeter, the difference will not be so marked, since the reduction to one-half of the magnetic flux in the armature (which represents the electromotive force) is compensated for by the fact that the series coils have doubled their flux with any given number of fifty-volt lamps as compared with the same number of one hundred-volt lamps.

The series coils of these meters, however, would suffer from overheating, since a one hundred-volt meter having a capacity of, say, fifty lights would never have to carry more than thirty amperes or an average of six-tenths of an ampere each, whereas if it be accidentally installed on a fifty-light, fifty-volt circuit, it will have to carry, when loaded, something like fifty-five amperes or nearly double for what it was designed.

It being true that all the lights in a residence are scarcely ever used at one time, it follows that, from a point of economy, it is wise to install a meter having a somewhat smaller capacity than that of the total number of lights. Taking, for instance, a residence having fifteen lights, a ten-light meter would answer very well, since the average number in use at any one time would not exceed eight or ten, and if all the lights should happen to be in use during an evening on some special occasion, the meter will take care of them all right, and without encountering any serious damage.

The following table, which gives the sizes of meters that may be used in residence lighting, the number of sixteen-candle-power lamps they can take care of, and the sizes of wire best suited for winding the series coils in order to withstand temporary overload, will be found useful, and at the same time answer questions very often asked by central station men:

Data of Meters.

Number of Lights Installed.	Size of Meter in Lights.	Gauge of Wire.	
		50 Volts.	100 Volts.
3 4 5 6 7	5	10	13
8 10 12 14	10	7	10
16 18 20	15	6	8
25 30 35	25	5	7
40 45 50 55 60 65	50	2	5
70 75 80 85 90 95 100	75	0	3

Too much stress cannot be laid upon the requirements necessary for the successful installing of meters. If these are not properly attended to, the neglect is sure to become a source of future annoyance, the results of which invariably work to the disadvantage of the owners of the plant.

The proper time to locate the place where the meter is to be installed is when the wiring is being done. This should be in a place easy of access and always dry, and, when possible, high enough above the floor that the person reading the meter will not have to get down on his knees. When they are placed in an attic (as is the case with ninety per cent. of them) they should be near a window, so that no matches, candles or oil lamps will have to be used to enable one to read them. Otherwise it is not only annoying and troublesome, but actually dangerous.

The meter must never be screwed up against a plastered wall, but should be fastened to a board which is itself screwed against the wall. This method is particularly commendable in large cities where there is a good deal of vibration in buildings caused by wagons, street cars and other heavy vehicles, this in time causing the meter to tilt through the screws becoming loose in the plaster, thus putting the meter out of level. This board can be large enough to accommodate a double-pole fuse block inserted in the line ahead of the meter—that is, between it and the transformer or other source of supply. This arrangement will be found much more convenient than that ordinarily practiced, or where the meter is installed at one part of the building and the fuse block in another. The necessary connections for coulomb and lamp-hour meters are shown in

Fig. 1, and Fig. 2 shows the method best adapted for watt-hour meters.

Care should be exercised in putting the line wires into the meter, and the set-screws should be firm, so as to make a good contact. It frequently happens that this is neglected, with the result that heat is developed at the binding posts, which invariably burns the wooden blocks to which the terminals or binding posts are screwed.

When the meter is installed, carefully inspect it to see that all the moving parts are free, and that no lint or other obstructive matter is adhering thereto, as this will tend to reduce the speed on very small loads. Examine the registering train to see that it is in proper working order, look over the pointers, and if bent, be sure to straighten them, or difficulty in reading will surely await the person who has this work to perform. When satisfied that these points are all right, next examine the worm wheel, which should mesh easily into the worm upon the shaft, and not be too taut, as this might cause jamming, thereby stopping the meter on small loads. It must also be remembered that this wheel and worm should not mesh too loosely, as this may also cause trouble. Then turn on one or two lamps to make sure that the circuit and meter are all right. I knew of a case several months ago in which the meter was installed in the morning, but without ascertaining whether everything was in readiness for operation or not; the consequence being that when evening came the people in the house could not obtain any light until they had waited several hours after notifying the station manager of the trouble. When the meter man arrived, he discovered that he had neglected to put fuses in the fuse block, which he would have noticed if he had only taken the precaution to test his circuit and meter before leaving them. After a meter is in circuit and before the cover is replaced, it should be noticed that the in-leading wires fill up the holes through which they pass into the meter, in order that the entrance of dust and insects may be prevented. If any space is around these leads, it must be filled up with tissue paper, or something much better in the form of asbestos paper made soft and pulpy by soaking it in water. The cover may now be replaced and sealed, when every thing will be in readiness for operation.

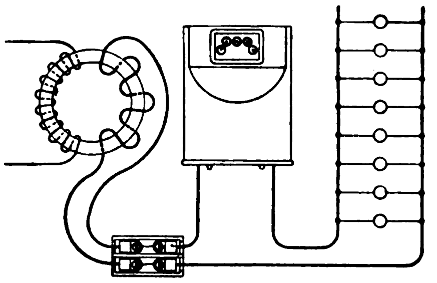


FIG. 1.—CONNECTIONS FOR COULOMB METER.

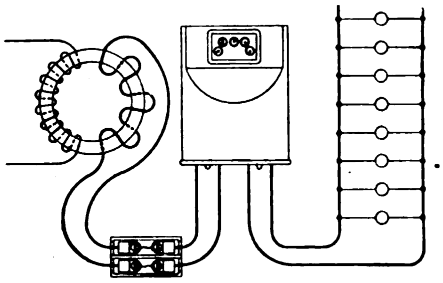


FIG. 2.—CONNECTIONS FOR LAMP-HOUR METER.

As a general rule, there is more or less trouble experienced in using meters for the first time, when it comes to reading them and collecting the bills; the former many times being due to the inexperience of the meter man, who may be entirely new in the business, and the latter being brought about by the prevailing and erroneous impression among the people that electric meters are, like their forerunner and present competitor, the gas meter, inaccurate. This appeals to their imagination all the more vividly when they know that electricity is of an intangible nature and a medium only known to exist by its effects.

If the meter be a lamp-hour instrument, the chances for checking by the consumer are without doubt the simplest and most easily understood. If he entertains any doubt in his mind as to its accuracy of operation, it is only necessary to keep a record of the number of lamps used during an evening and their time of use, or the number of hours they have been burning, when the product of these two quantities will give the reading of the meter. If it be an ampere-hour meter, it becomes necessary that he be made acquainted with what is meant by the unit "ampere," which can without much difficulty be explained to him so as to be intelligently understood. When a watt-meter is employed for measuring the energy, it is not quite so easy to make him understand what he is paying for, and in many cases a consumer has a disposition not to pay for anything he does not quite understand. This, of course, is natural, but yet I have heard central station men express a desire for wattmeters, since the mere fact of their customers not understanding what a watt-hour is, makes them less liable to check up the readings of the meter, as is easily accomplished with a lamp-hour meter.

Many instances are on record in which the persons reading the meters claimed that they ran backwards. This mistake is very easily understood by those who have had a wide experience with meters, and one that is possible only through mistakes in reading; therefore every precaution should be exercised in order that such mistakes do not occur, as they not only help to destroy the confidence in the meter, but in many cases it is actually the means of having it removed as faulty.

In reading the dial the best practice is to commence at the right hand side and read towards the left, at the same time taking great care that the proper numerals are set down, as it is in this that mistakes are most frequently made. A case came to the notice of the writer last winter, through a complaint which purported that a certain meter had read or rather had run backwards during the last month. The matter was investigated, and the following data will serve to show how the mistake occurred:

Reading	1st month	486	lamp	hours.
"	2d "	838	"	"
"	3d "	1206	"	"
"	4th "	2817	"	"
"	5th "	2274	"	"

It will be seen at a glance, that the customer had every reason to complain of his bill for the fourth month, as it was much too high, yet the station man held that he must have used the light, as the meter was giving entire satisfaction up to that time, and subsequent tests had proved it to be yet correct. The matter was patched up some way, and the following month disclosed the fact, they said, that the meter had been running backwards that month, when it was evidently running too fast the month before. It is safe to assert, however, that the reading of the fourth month was an error, and in all probability should have been and was 1817 instead of 2817. It may have been due to the person glancing at the thousand pointer, and noticing it to be nearer to the numeral 2 than 1, he put it down as 2 in his book or record—evidently forgetting for the moment that it could not be 2 until the hundred hand or pointer had reached 0 again.

In reading watt-hour meters it is customary to read them as you would a gas meter; that is, the number given over or under the circle representing the value of one complete cycle or revolution of its pointer. If 1000 is over the first or right hand circle and it is divided into ten, the value of each will be 100. This is not the case with the ampere and lamp-hour meters, as the number placed over and under the circle represents the value of each division of that circle. This sometimes causes a little confusion with those using both types, but after becoming familiar with the meters a mistake seldom happens.

Another difficulty into which purchasers fall occurs when it is decided to use ampere-hour meters in preference to something else, and they start out by telling their customers that it will now cost them, say, one cent per ampere-hour. This works all right, probably, on the 50-volt circuits; but when they take the readings on the meters which have been installed on 100-volt circuits, they discover that something is wrong; the meter has only indicated one-half what it should have registered in their estimation. It was evidently not considered that the 100-volt lamps required only half an ampere, registering only approximately one-half the number of ampere hours that they would on a 50-volt circuit; hence customers have to be notified that they are using 100-volt lamps, and, therefore, the rate must be doubled. This necessitates the use of two rates; one for 50-volt circuits and another for 100-volt circuits.

If the foregoing double rate does not meet with approval, the only alternative is to reduce the reading on either voltage to watt-hours, and use a single rate of so much per 1000 watt-hours. For simplicity's sake let us take the following example:

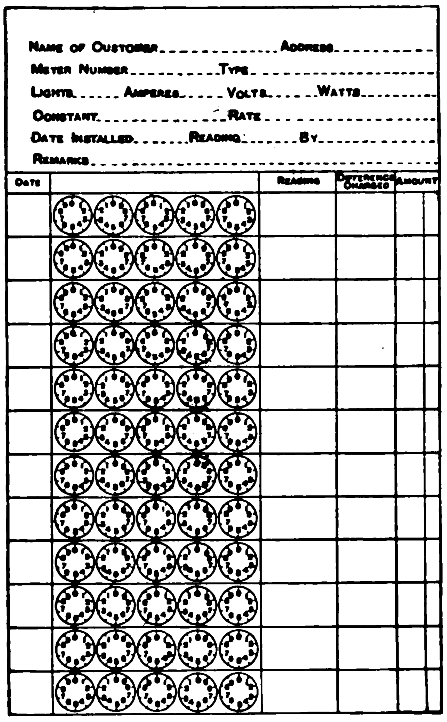
If we take an ampere-hour meter in circuit with twenty lamps of fifty volts each and for a period of ten hours, the reading of the meter at the expiration of this time will be 200 ampere-hours (that is, of course, on the assumption that these lamps take, on an average, one ampere each). This at one cent per ampere-hour will be $2. But to reduce this reading to watt-hours, we take the product of the ampere-hours and the voltage of the circuit, which will be in this case 200 × 50 = 10,000 watt-hours; this at twenty cents per 1000 watt-hours will be $2. Let us now put this same meter in circuit with twenty lamps of 100 volts each and for the same time (ten hours), and the reading will be twenty lamps of one-half ampere each, or ten amperes times ten hours, equal to 100 ampere-hours at two cents per ampere-hour (100-volt rate), or $2. The reduction to a watt-hour basis will be the reading of the meter in ampere hours multiplied by the voltage of the circuit or 100 × 100 = 10,000 watt-hours, which at twenty cents per 1000 will be $2.

The following equivalent charges will be found useful in computing the cost of lighting:

METER RATES.

Lamp Meter	Ampere Meter		Wattmeter
50 and 100 volts	50 volts.	100 volts	50 and 100 volts
$.0200	$.0200	$.0400	$.4000
.0150	.0150	.0300	.3000
.0100	.0100	.0200	.2000
.0090	.0090	.0180	.1800
.0080	.0080	.0160	.1600
.0075	.0075	.0150	.1500
.0070	.0070	.0140	.1400
.0060	.0060	.0120	.1200
.0050	.0050	.0100	.1000

Complaints when received from customers should be attended to immediately, not only to maintain the good will of the customer, but as a means of showing that the business is conducted in a first class manner. If the complaint is to the effect that his meter is running too fast, make a test of it before him in order that he may be fully satisfied. The method of taking down a meter upon the slightest complaint and replacing it with another only aggravates matters and gives the customer the impression that he was right in his convictions whether the meter was at fault or not. It is time enough to remove the meter when the man in charge is satisfied that it is not working properly.


NAME OF CUSTOMER.................ADDRESS..........
METER NUMBER...........TYPE.....................
LIGHTS.....AMPERES.....VOLTS.....WATTS..........
CONSTANT...............RATE.....................
DATE INSTALLED........READING........BY.........
REMARKS...

DATE		READING	DIFFERENCE CHARGED	AMOUNT

FIG. 3.—METER RECORD.

When a meter is taken down for repairs, it is always best to repair it as soon as possible or convenient, or while the probable fault or faults are yet fresh in the memory, since putting it away on some shelf or dark corner until a rainy day comes is sure to find a week's work to be done. If necessity requires its being laid away for the time being, a slip of paper should be put inside the cover bearing the name of its last user, its size, and the probable faults accountable for its action and for which it was removed.

The best success will be attained if a thorough record of all the meters be kept by the person in charge. A book with a page similar to Fig. 3 can be procured from meter manufacturers at a small cost, which will save a great deal of useful time and prevent many disagreeable disputes.

Another convenient method of insuring accuracy would be to use a number of these slips, consisting of the heading shown in Fig. 3, with only one row of circles and padded together. One of these slips can be filled out for each meter as the reading is taken, then all handed in to the bookkeeper from which to make out his bills.

When the reading of the meter is taken it should be done by putting a mark directly upon the circles of the record book to correspond with the readings on those of the meter dial. In this way not only the numerical amount, but the actual position of the pointers on the several circles is on record in case of a complaint being made afterwards.

A very good way of keeping the consumers informed is to have a slip of paper or card hanging beside the meter with his name and the number of the meter printed thereon, and as the readings are taken each month, they should be put down upon this card, at the same time taking good care that the reading placed thereon agrees with the official records.

To guard against curious and meddlesome customers who are ever present, the meter should be well sealed so that there is no possible way of interfering with its operation without leaving signs or marks of that character.

◆

Armour Institute.

The Year-Book of the Armour Institute shows the faculty to contain no less than 33 members, who are reinforced by a number of lecturers, among whom we note Prof. H. S. Carhart and Mr. Fredk. H. Loveridge. The electrical engineering course, in charge of Prof. Wilbur M. Stine, is adapted to the latest requirements of electrical engineering. Chemistry, for example, occupies a leading place in the curriculum, thus recognizing the growing importance of electro-chemistry and electro-metallurgy.

◆

Modern American Transformers.

Bulletin No. 11 of the Univ. of Wisconsin is a valuable electrical monograph, giving all of the details and the results of a complete test of modern American transformers of moderate capacities. The author is Mr. Arthur Hillyer Ford, fellow of electrical engineering of the University. The report, which covers no less than 88 octavo pages and includes 39 illustrations, is prefaced by a note by Prof. D. C. Jackson, which lays down the points that the central station man should observe in purchasing transformers.

COMMUTATOR BRUSHES FOR DYNAMO-ELECTRIC MACHINES; THEIR SELECTION, THEIR PROPER CONTACT AREA AND THEIR BEST TENSION.

By ALFRED E. WIENER, E.E., M.E., M.A.I.E.E.

In designing dynamo-electric machinery, care should not only be exercised in the direction of obtaining the best possible dimensions, windings and electrical and magnetica efficiencies, but the desideratum should also be to produce machines of best *performance* when subjected to working conditions. But the performance of a dynamo when running depends chiefly upon the design of the current collecting device; the commutator brush, in consequence, is one of the most important parts of a dynamo-electric machine, and its design, in order to achieve best results, should be worked out with as much attention as that of the field frame or of the armature.

The proper design of the commutator brush consists (1) in the selection of the material and form best suitable for the particular purpose; (2) in an appropriate dimensioning of the brush contact area, in accordance with the current output of the machine in question; and (3) in the determination of the most favorable brush-tension.

1. Material and Kinds of Brushes.—For low potential machines having a large current output, such as incandescent lighting generators, electro-plating dynamos and machines for electro-metallurgical purposes, it is the practice to employ thick *copper* brushes, made up either of copper wires or copper strips, or copper wire gauze, in order to secure a large number of contact points and to set them so as to make an angle about 45 degs. with the commutator surface, as shown in Fig. 1. In small dynamos often springy copper plates are used which are placed tangentially to the commutator periphery, as illustrated in Fig. 2. For high potential machines, especially for railway generators and motors, *carbon* brushes are used in order to aid in the sparkless collection of the current at varying load. As each commutator segment enters under the brush, the area of contact is, at first, very small, and, owing to the high specific resistance of carbon, a considerable resistance is offered to the passage of the current from the branch of the armature of which that segment at the time is the terminal, into the external circuit. This gives rise to a considerable local fall of potential, which diverts a comparatively large portion of the armature current through the neighboring coil into which it flows against the existing current, causing the latter to reverse quickly in opposition to the E. M. F. of self-induction,

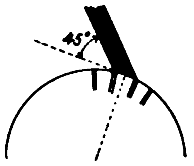


FIG. 1.—SLOPING COPPER WIRE- (OR LEAF-) BRUSH.

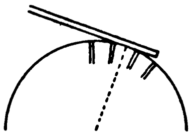
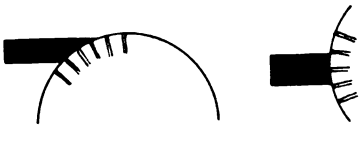


FIG. 2.—TANGENTIAL COPPER PLATE BRUSH.

thereby preparing the short-circuited coil to join the successive armature circuit of opposite polarity without sparking. The resistance of the carbon brushes cannot be depended upon for the complete commutation of the entire current, but in most generators, especially those with toothed and perforated armatures, fully half the armature current may be thus commutated. In railway generators it is usual to adjust the brushes so that at no load they are in the neighborhood of the forward pole-tips where the pole-fringe E. M. Fs. generated are sufficient to reverse one-half of the normal current, the remaining half being then taken care of by the carbon brushes.

Carbon brushes are either set tangentially (Fig. 3), or radially (Fig. 4) with respect to the commutator circumference, the latter arrangement having the advantage of admitting of reversal of the rotation without changing the brushes.



FIGS. 3 AND 4.—TANGENTIAL AND RADIAL CARBON BRUSH.

To use carbon brushes exclusively on machines of low voltage would be very bad practice, because carbon has so much higher resistance than copper, that the drop of potential would be excessive, and too great a percentage of the power of the machine would be used up for commutation. If, therefore, the resistance of an ordinary copper brush is not high enough for sparkless collection, a copper gauze brush must be employed which has a much higher resistance than a copper leaf brush, and while there are some mechanical advantages in using it, such as cooling effects and smoother wear of the commutator, yet the principal reason it stops sparking is that it has a higher resistance. In case the resistance is still too low, the next step is the application of a *brass* gauze brush having about twice the resistance of copper gauze. If that is not enough yet, some form of carbon brush which has its resistance reduced, must be resorted to. Carbon itself cannot have its resistivity changed, but by mixing copper filings with the carbon powder, or by moulding layers of gauze in it, the conductivity of the brush can be increased. Instead of artificially decreasing the resistance of carbon, *combination brushes* consisting either in copper brushes provided with carbon tips (Fig. 5), or in carbon brushes sliding upon the commutator and having, in turn, copper brushes resting against themselves (Fig. 6), are sometimes employed, and in case of very heavy currents the addition to each set of copper brushes, of a combination brush set somewhat ahead of the copper brushes, as shown in Fig. 7, has been found to greatly improve the sparkless running of the machines. With the latter arrangement the tension on the combination brushes should exceed that on the copper brushes sufficiently to enable them to take their full share of the current as nearly as possible.

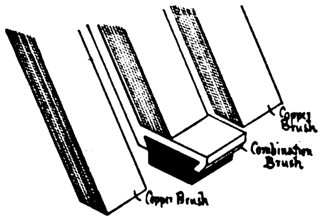
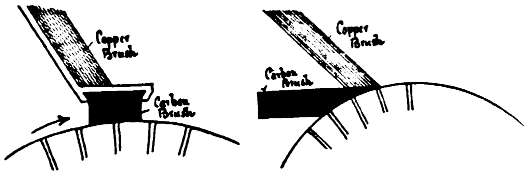


FIG. 7.—ARRANGEMENT OF COPPER AND COMBINATION BRUSHES FOR COLLECTION OF LARGE CURRENTS.



FIGS. 5 AND 6.—COMBINATION COPPER-CARBON BRUSHES.

2. *Area of Brush Contact.*—The circumferential thickness of the brushes—according to the current capacity of the machine, to the grouping of the armature coils, to the material and kind of the brush, and to the dimensions of the commutator—varies between less than the width of one to that of three and even more commutator segments. In case the brush covers not more than the width of one bar, as in Fig. 8, only one armature coil is short-circuited at any time, while in the case of brushes thicker than one bar plus two side-insulations (Fig. 9), two or even more coils, at times, are simultaneously short-circuited under each set of brushes.

The breadth of the brush contact surface in the former case (Fig. 8) is equal to the thickness of the beveled end of the brush measured along the commutator circumference; in the latter case (Fig. 9) it is the breadth of the brush bevel diminished by the sum of the thicknesses of the commutator insulations covered by the brush, and can be generally expressed by the formula:

$$b = n \times \left(\frac{d \times \pi}{N} - i \right) \quad . \; . \; . \; . \; (1)$$

where b = circumferential breadth of brush contact, in inches;
n = number of commutator bars covered by the thickness of one brush;
d = diameter of commutator, in inches;
$d \times \pi$ or $3.14 \times d$ = circumference of commutator in inches;
N = number of commutator divisions;
i = thickness of commutator side insulation, in inches;
i = .020″ to .030,″ for dynamos up to 300 volts E.M.F.,
= .030″ to .040,″ " " from 400 to 750 volts,
= .040″ to .060,″ " " " 800 to 3,000 volts.

If the brush covers less than one bar, as in Fig. 8, n is a fraction; if the width of the brush is from one bar to one bar plus two side insulations, $n = 1$; when between two bars plus one insulation and two bars plus three insulations $n = 2$, etc.; and if the brush covers from one bar plus two insulations to two bars plus one insulation, or from two bars plus three insulations to three bars plus two insulations, etc., the value of n is a mixed number consisting in an integer and a fraction.

Having decided upon n, and having calculated b from (1), the width of the contact area, and subsequently the width of the brushes, can be found for a given current output of the dynamo by providing contact area in proportion to the current intensity. In order to keep the brushes at a moderate temperature, and the "loss of commutation" within practical limits, the current density of the brush contact should not exceed 150 to 175 amperes per square inch in case of copper brushes (wire, leaf, plate and gauze), 100 to 125 amperes for brass gauze brushes, and 30 to 40 amperes in case of carbon brushes. Or, specific contact area should be provided at the rate of from 5700 to 6700 sq. mils per ampere for copper brushes, from 8000 to 10,000 sq. mils per ampere for brass gauze brushes, and from 25,000 to 33,300 sq. mils per ampere for carbon brushes.

Taking the lower of the above limits for the current densities, the effective length of the brush contact can be expressed by

$$l = \frac{C}{150 \times p \times b}, \quad . \; . \; . \; . \; . \; . \; . \; . \; (2)$$

for *copper* brushes, by

$$l = \frac{C}{100 \times p \times b}, \quad . \; . \; . \; . \; . \; . \; . \; . \; (3)$$

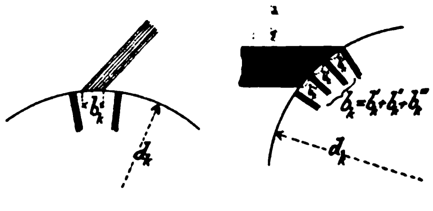
for *brass* brushes, and by

$$l = \frac{C}{30 \times p \times b}, \quad . \; . \; . \; . \; . \; . \; . \; . \; (4)$$

for *carbon* brushes, the symbols employed being:

l = effective length of brush contact surface, in inches;
$= s \times w$ (s = number of brushes per set, w = width of brush);
C = total current output of dynamo, in amperes;
p = number of pairs of brush sets (usually either $p = 1$, or is equal to the number of divisions of the armature current).

For the purpose of securing a good contact, the length, l, should be subdivided into a set of s individual brushes of a width, w, each, not exceeding 1½ to 2 ins. In small machines where one such brush would suffice, it is good practice to employ two narrow brushes, even down as low as ⅜ in. each, in order to facilitate their adjusting or exchanging while the machine is running.



FIGS. 8 AND 9.—CIRCUMFERENTIAL BREADTH OF BRUSH CONTACT.

As an illustration of the use of the above formulæ. The brush contact surface for a 500-volt 150-ampere generator is to be computed, the commutator of which has ninety divisions and a diameter of ten inches, and which has two sets of tangential carbon brushes, each covering the width of two commutator bars. In this case $n = 2$, $d = 10$, $N = 90$, and the thickness of the commutator insulation, which for 500 volts should be taken between .030 and .040, is assumed

$i = .036$. According to formula (1), therefore, the breadth of the contact area is

$$b = 2 \times \left[\frac{10 \times 3.14}{90} - .036\right] = .626 \text{ in.} = \tfrac{5}{8} \text{ in.}$$

As carbon brushes are used, formula (4) is to be employed for the length of the brush contact; for $C = 150$, $p = 1$ and $b = \frac{5}{8}$, we have

$$l = \frac{150}{30 \times 1 \times \frac{5}{8}} = 8 \text{ ins.}$$

The machine in question thus requires a contact area of ⅝ in. × 8 ins. for each set of brushes, or, there should be four carbon brushes of ⅝ in. × 2 ins. cross section in each of the two brush sets.

3. Energy-Loss in Collecting Armature Current. Determiaation of Best Brush-Tension.—The brushes give rise to two losses of energy: An *electrical* energy loss, due to overcoming contact resistance, and a *mechanical* loss, caused by friction. Both of these losses depend upon the pressure with which the brushes are resting upon the commutator, the electrical loss decreasing and the mechanical loss increasing with increasing brush-tension. There will, therefore, in every single case, be one certain pressure per unit area of brush contact, for which the sum of the brush losses will be a minimum. With the object of determining this critical pressure, E. V. Cox and H. W. Buck[*] have investigated the influence of the brush tension upon the contact resistance and upon the friction, for various kinds of brushes. They found (1) that the friction increases in direct proportion with the tension; (2) that the contact resistance decreases at first very rapidly, but that beyond a certain point a great increase in pressure produces only a slight diminution of resistance; (3) that slightly oiling the contact surface, while not perceptibly increasing the electrical resistance, greatly diminishes the friction; (4) that for a copper brush the friction is greater and the contact resistance smaller than for a carbon brush of the same area at the same pressure; (5) that the friction of a radial carbon brush is greater than that of a tangential carbon brush at the same pressure; (6) that for the same brush both the contact resistance and the friction are considerably less on a cast iron cylinder than on a commutator, and (7) that for all kinds of brushes the friction is less at high than at low peripheral speeds, while the contact resistance is but slightly increased by raising the velocity.

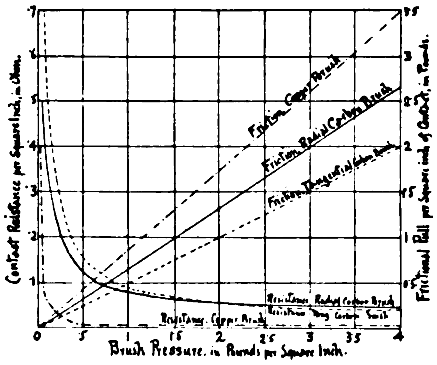


FIG. 10.—CONTACT RESISTANCE AND FRICTION PER SQ. IN. OF BRUSH SURFACE ON COPPER COMMUTATOR (DRY) AT PERIPHERAL VELOCITY OF 1000 FT. PER MIN.

In Figs. 10 and 11 the averages of their results are plotted, the former giving the curves of contact resistance and friction for an ordinary commutator without lubrication, and the latter the corresponding curves for the case that the commutator is replaced by a cast iron cylinder.

From Fig. 10 the following table is derived which, in addition to the data obtained from the curves, also contains the brush friction for the case that the commutator is slightly oiled.

CONTACT RESISTANCE AND FRICTION FOR DIFFERENT BRUSH TENSIONS.

Brush Tension in pounds per sq. inch.	Contact Resistance per square inch of Brush Surface, r, in ohm.			Tangential Pull due to Brush Friction per square inch of contact at peripheral speed of 1,000 ft. per minute, f, in pounds.					
				Commutator Dry.			Commutator Oiled.		
	Tangential Copper Leaf Brush.	Tangential Carbon Brush.	Radial Carbon Brush.	Tangential Copper Brush.	Tangential Carbon Brush.	Radial Carbon Brush	Tangential Copper Brush.	Tangential Carbon Brush.	Radial Carbon Brush.
.5	.010	.50	.40	.6	.3	.5	.16	.10	.15
1	.009	.24	.20	1.15	.63	1	.32	.20	.30
1.5	.008	.15	.13	1.7	.95	1.5	.48	.30	.45
2	.007	.12	.10	2.25	1.25	2	.64	.40	.60
2.5	.006	.10	.087	2.8	1.6	2.5	.80	.50	.75
3	.0055	.09	.08	3.4	1.9	3	.96	.60	.90
3.5	.0052	.083	.075	3.95	2.2	3.5	1.12	.70	1.05
4	.005	.08	.07	4.5	2.5	4	1.30	.80	1.20

The specific pull, f, due to brush friction, in columns 6 to 10 of the above table is given for a peripheral velocity of 1000 ft. per minute; at 2000 ft. per minute it is ⅞; at 3000 ft. per minute, ¾; at 4000 ft. per minute, ⅝, and at 5000 ft. per minute only ½ of what it is, for that pressure, at 1000 ft. per minute; and for any commutator velocity, v, can be found from the formula:

$$f' = f\left(1 - \frac{v - 1000}{8000}\right) \quad \ldots\ldots\ldots (5)$$

From the above table the electrical brush loss is calculated by dividing the contact resistance given for the particular brush tension employed by the contact area and multiplying the quotient by the number of sets of brushes and by the square of the current passing through each set, thus:

$$P = 2p \times \frac{r}{A} \times \left[\frac{C}{p}\right]^2 = 2 \times \frac{r \times C^2}{A \times p} \text{ watts}$$

$$= .00268 \times \frac{r \times C^2}{A \times p} \text{ horse power, (6)}$$

where $P =$ energy absorbed by contact resistance of brushes, in HP;
$r =$ resistivity of brush contact, in ohm per square inch surface, from table;
$A =$ contact area of one set of brushes, in square inches; $A = b \times l$;
$p =$ number of pairs of brush sets;
$C =$ current output of dynamo.

And the frictional loss is obtained by multiplying the tangential pull, given for the respective brush tension, and corrected to the proper peripheral velocity according to formula (5), by the total brush contact area and by the peripheral velocity of the commutator, and dividing the product by 33,000 the equivalent of one horse power in foot-pounds per minute:

$$P_1 = \frac{f' \times 2p \times A \times v}{33{,}000}$$

$$= 6 \times 10^6 \times f' \times A \times p \times v \text{ HP.} \quad \ldots\ldots (7)$$

in which $P_1 =$ Energy absorbed by brush friction in HP;
$f' =$ specific tangential pull, due to friction, at velocity v, in pounds; see formula (5);
$2pA =$ total area of brush contact surfaces in square inches;
$v =$ peripheral velocity of commutator in feet per minute,
$= \frac{d \times \pi}{12} \times S$ ($d =$ diameter of commutator, in inches, S = speed of dynamo, in revolutions per minute.)

By calculating the amounts of P and P_1, from (6) and (7), respectively, for various trial brush tensions, the best tension giving a minimum value of the total brush loss, $P + P_1$ can readily be found.

For the machine considered in the example above the best brush-tension is calculated as follows: Supposing an armature speed of $S = 900$ r. p. m., the peripheral velocity of the commutator is found

$$v = \frac{10 \times 3.14}{12} \times 900 = 2360 \text{ ft. p. m.,}$$

and therefore from (5)

$$f' = \left[1 - \frac{2360 - 1000}{8000}\right] \times f = .83 f.$$

For $p = 1$ pair of brush sets, $C = 150$ amps. and $A = \frac{5}{8} \times 8 = 5$ sq. ins.; we now compute the total power absorbed by the brushes at various tensions. For a pressure of 1 lb. p. sq. in. the table gives $r = .24$ ohm and $f = .63$ lb. when the commutator is dry. Correcting the latter figure for the proper velocity we obtain $f' = .83 \times .63 = .523$ lb.

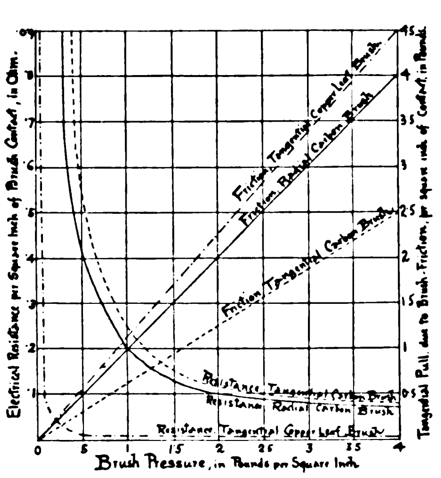


FIG. 11.—CONTACT RESISTANCE AND FRICTION PER SQ. IN. OF BRUSH SURFACE ON CAST IRON CYLINDER.

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[*] "The Relation Between Pressure, Electrical Resistance and Friction in Brush Contact," Electrical Engineering Thesis, Columbia College, by E. V. Cox and H. W. Buck. *Electr. Engineer*, Vol. XX, p. 125 (Aug. 7, 1895; *Electr. World*, Vol. XXVI, p. 217 (Aug. 24, 1895).

From formula (6), consequently, the power absorbed by contact resistance is found

$$P = .00268 \times \frac{.24 \times 150^2}{5 \times 1} = 12.05 \times .24$$
$$= 2.89 \text{ HP},$$

while formula (7) gives the power consumed by friction:

$$P_1 = 6 \times 10^{-5} \times .523 \times 5 \times 1 \times 2360$$
$$= .708 \times .523 = .37 \text{ HP}.$$

Hence the total power used for collecting the current, at a brush-tension of 1 lb. per sq. in. of brush contact surface:

$P + P_1 = 2.89 + .37 = 3.26$ HP.

For 2 lbs. per square inch, $r = .12$ and $f = 1.25$, or $f' = .83 \times 1.25 = 1.04$; consequently:

$P = 12.05 \times .12 = 1.45$ HP.

$P_1 = .708 \times 1.04 = .74$ HP.

$P + P_1 = 1.45 + .74 = 2.19$ HP.

Similarly, for 2½ lbs. per square inch, $r = .10$, $f = 1.6$, $f^1 = .83 \times 1.6 = 1.33$.

$P = 12.05 \times .10 = 1.205$ HP.

$P_1 = .708 \times 1.33 = .94$ HP.

$P + P_1 = 1.205 + .94 = 2.145$ HP.

And for 3 lbs. per square inch, $r = .09$, $f = 1.9$, $f' = .83 \times 1.9 = 1.58$.

$P = 12.05 \times .09 = 1.085$ HP.

$P_1 = .708 \times 1.58 = 1.12$ HP.

$P + P_1 = 1.085 + 1.12 = 2.205$ HP.

The total power here being observed to increase again, 2½ lbs. per square inch, producing the minimum value of $P + P_1$, is found to be the best brush tension, if no lubrication is used.

If oil is to be applied to the commutator the values of f_1 P_1, and $(P + P_1)$ are as follows:

For the tension of 2 lbs. per sq. in.: $f = .4$,

$P_1 = .708 \times .83 \times .4 = .588 \times .4 = .235$ HP.

$P + P_1 = 1.45 + .235 = 1.685$ HP.

For 3 lbs. per sq. in.: $f = .6$,

$P_1 = .588 \times .6 = .35$ HP.

$P + P_1 = 1.085 + .35 = 1.435$ HP.

For 3.5 lbs. per sq. in.: $r = .083$, $f = .7$,

$P = 12.05 \times .083 = 1.00$ HP.

$P_1 = .588 \times .7 = 41$ HP.

$P + P_1 = 1.00 + .41 = 1.41$ HP.

For 4 lbs. per sq. in.: $r = .08$, $f = 8$,

$P = 12.05 \times .08 = .964$ HP.

$P_1 = .588 \times .8 = .47$ HP.

$P + P_1 = .964 + .47 = 1.434$ HP.

In this case the minimum value of the total power indicates that 3½ lbs. per sq. in. is the most economic brush tension.

* * * *

If the commutator brushes of dynamo-electric machines are designed in accordance with the above considerations, the heating of commutator and brushes will be small, the energy losses of commutation will be reduced to a minimum, and the sparking will be limited—the fundamental conditions for excellence in performance.

SPEED REGULATION OF INDUCTION MOTORS.

By P. M. Heldt.

There is a great similarity in some respects between shunt wound, continuous current motors and alternating current induction motors, a fact that was first pointed out by Mr. Goerges.[*] This similarity is especially apparent when the methods by which speed regulation is effected in the two types of motors are reconsidered. Before commencing the discussion of speed regulation in induction motors we will therefore briefly resume the methods by which the speed of continuous current shunt motors is controlled.

The two equations expressing the relation between the different factors entering into the operation of these last named motors may be stated as follows:

$$\text{Speed} = \frac{\text{a constant} \times \text{back E. M. F.}}{\text{armature flux} \times \text{armature conductors}}$$

and

$$\text{torque} = \text{a constant} \times \text{armature flux} \times \text{armature conductors} \times \text{armature current.}$$

From the first equation it will be seen that the speed may be varied by varying either the back E. M. F., the magnetic flux through the armature or the number of effective conductors on the armature.

The back E. M. F. may be decreased by decreasing the applied E. M. F., say, by introducing a resistance into the circuit if the voltage of the supply circuits is constant. This would involve a reduction of the magnetic flux through the armature, but under ordinary conditions the decrease in the back E. M. F. will be proportionally greater than the decrease in the armature flux, and consequently the speed will drop. If the resistance, instead of being placed in the main circuit, is connected in series with the armature circuit, the reduction of speed will be more pronounced, as the field retains its original strength. This method is also better from an economic standpoint, and is the one most frequently met with in practice.

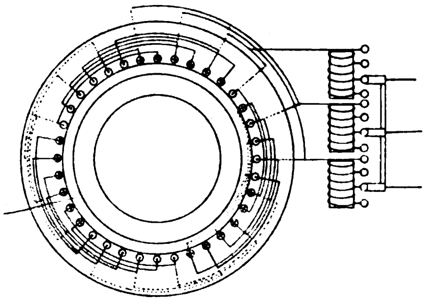

FIG. 1.—THREE-PHASED MOTOR WITH INDUCTIVE RESISTANCE.

The number of effective armature conductors may be decreased by shifting the brushes from the neutral point. It is a well known fact that a motor runs slowest when the brushes are set on the neutral points and either a lag or lead given them will increase the speed, especially at light loads.

This principle is, however, of not much practical value, as the angle through which the brushes may be shifted is generally quite limited by sparking.

The armature may be wound with two or more windings, each having its own commutator, which can be connected in series or in parallel. Taking as an example a motor with two windings we find that the number of effective armature conductors is equal to the number of conductors of one winding when the two are connected in parallel, and equal to twice that number when they are connected in series. With the latter connection the motor will, therefore, run at only one half the speed as with the former. For intermediate speeds a resistance can be connected in series with the armature as explained above.

When the load on the motor is light, the speed may also be increased by placing a resistance in the field coil or a magnetic shunt across the armature, both means of reducing the armature flux.

The two equations given above may be so modified as to express the conditions of operations of an induction motor. First it should be considered that the speed to which the E. M. F. induced in the armature windings is proportional is not necessarily the absolute speed of the motor, but the relative speed between armature conductors and the magnetic field. In an induction motor the magnetic field rotates with a constant velocity. The velocity of the armature is always less than that of the magnetic field, and the difference between the two is called the slip. It is this quantity that has to be substituted for speed in the first of the above equations. It is also advantagous to express the induced E. M. F. of the armature (the equivalent of the back E. M. F. of the shunt motor) as the product of its two factors—armature current and armature impedance. We may then write

$$\text{Slip} = \frac{\text{a constant} \times \text{armature current} \times \text{armature impedance}}{\text{armature conductors} \times \text{armature flux}}$$

On account of magnetic leakage the magnetic fields of the stationary and rotatory parts of the magnetic circuit are out of phase. The phase difference will increase somewhat with load, as the magnetic leakage increases with armature reaction. In well designed motors working inside the limit of their rated capacity, the leakage does not vary much. We may therefore include the factor representing the effect of the leakage on the torque in the constant of the equation. The value of the torque is then the same as before

$$\text{Torque} = \text{a constant} \times \text{armature conductors} \times \text{armature flux} \times \text{armature current.}$$

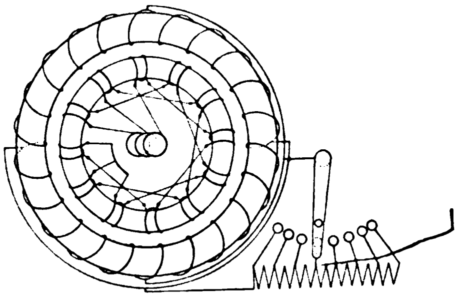

FIG. 2.—THREE-PHASED MOTOR WITH NON-INDUCTIVE RESISTANCE.

The E. M. F. applied at the terminals of the motor may be decreased by inserting either an inductive or a non-inductive resistance into the circuit. A highly inductive resistance would, of course, be preferable as it consumes but very little energy. The immediate results of reducing the primary applied E. M. F. would be a reduction of primary current and consequently fewer lines of force through the magnetic circuit.

Fig. 1 shows diagrammatically the winding of a 6-pole three-phased motor. The primary is a drum winding and is connected in triangle. The motor is connected to a regulator consisting of an inductive resistance.

Fig. 2 shows diagrammatically a 4-pole three-phased motor with rotating primary winding: a non-inductive resistance is inserted in the secondary for regulation. Both primary and secondary are ring-wound and the primary has a star connection.

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[*] Electrotechnische Zeitschrift 1894, p. 644.

Referring now to the expression for torque, we see that the armature current has to be increased in order to keep up the torque. But the equation of the armature current says that the greater the armature current the greater the slip, and a greater slip means a lower speed. Thus reducing the applied E. M. F. reduces the speed the same as in a continuous current motor. The alternating current motor has one advantage in that the reduction of potential may be effected with less expenditure of energy by using, as pointed out above, a highly inductive resistance. On the other hand, the increase in the armature loss is the same as in the continuous current motor.

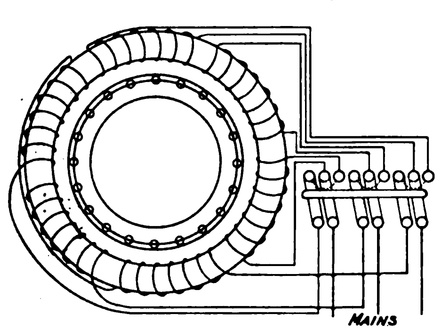


FIG. 3.—THREE-PHASED MOTOR WITH POLE-CHANGING SWITCH.

The second method of reducing the speed of the shunt motor was to place a resistance in the armature circuit. The same may be done with an induction motor. An increase of impedance in the armature circuit with the same current requires a greater induced E. M. F. and consequently a greater slip.

The armature may be wound with a double winding which can be connected in different ways, and a special form of such a double winding was described and illustrated in a former article[†] by the author.

A more efficient method and one especially suited where large variations of speed are required consists in connecting the primary winding to a regulating switch in such a manner that the number of poles may be reduced to one-half or any other fraction of the original number by operating the switch.

The angular speed of the rotating magnetic field is reduced in the same ratio as the number of poles which is also approximately the case with the speed of the motor. At the same time, the magnetic density in armature and field increases, and the output at the same percentage of slip may remain the same in spite of the reduction of speed. The accompanying table, published by Dr. Behn Eschenberg in *Electrotechnische Zeitschrift* (1896, p. 12), gives some experimental data of a three horse-power, three-phase Oerlikon induction motor. The field is wound with twelve coils which, by means of a regulating switch, can be so connected as to form either eight, four or two poles. It is stated that particular attention was paid to keeping the capacity and "no-load current" constant.

The following table shows that by means of this method the speed may be reduced to one-fourth the highest value without much sacrifice in output and efficiency. Where a gradual reduction of speed is required it has to be supplemented, however, by some other other method.

No. of Poles.	Rev. per min.	Torque in lb. ft.	Efficiency in per ct.	Output in H. P.	Curr'nt in amperes.
2	1700	0	......	......	9
2	2650	5.78	77	3	13
2	0	10.12	......	......	90
4	1350	0	......	......	9
4	1320	11.56	75	3	13
4	0	23.12	......	......	60
8	675	0	......	......	9
8	640	20.24	70	2.5	13
8	0	70.12	......	......	35

Fig. 3, shows a three-phased motor winding with "cage" armature winding. With the regulator set as shown the motor has two poles. With the regulator in the other position it has four poles.

The angular velocity of the magnetic field depends on the number of poles and the frequency of the primary current. The same result obtained above by varying the number of poles may therefore be arrived at by varying the frequency of the primary current. A device for changing the frequency of an alternating current has been invented by Prof. Rowland. It is called a frequency transformer. It consists of a phase transformer combined with a commutating device, the commutator or the brushes bearing thereon revolve, and by changing the speed of revolution the frequency of an alternating current may be changed to any value from zero up. Such a device when practically perfected should prove of great value in the economic regulation of induction motors.

The last method of regulation we will mention consists in varying the strength of the magnetic field. This may be done by providing the motor with a multiple primary winding, the parts of which can be connected in series or parallel. When connected in parallel large temporary overloads may be put on the motor. In a continuous current motor the magnetic density is generally not far below the point of saturation and can therefore not be increased to any great extent. In an induction motor the magnetic density is generally kept much lower in order to keep down eddy current and hysteresis losses.

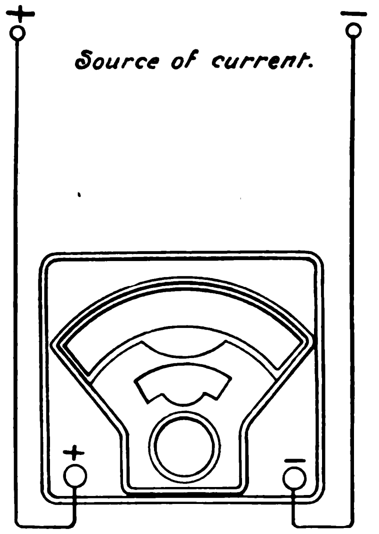


FIG. 1.—CONNECTIONS TO LINE.

An advantage of induction motors over shunt motors in regard to overload carrying may be pointed out here. In a shunt motor the extra heating due to an overload is all confined to the armature winding, while in an induction motor when the last named method of regulation (or the one of changing the number of poles) is employed, the extra heating of an overload is distributed over the primary winding, the whole of the magnetic circuit and possibly also the secondary circuit. Consequently it takes a great deal of extra heating before any part of the motor reaches a dangerous temperature.

◆

THE WESTON VOLTMETER USED AS AN INSTRUMENT FOR MEASURING HIGH RESISTANCES.

BY PROF. A. F. MCKISSICK.

For measuring high resistances, the Weston direct-reading voltmeter can be used sometimes to great advantage when the proper current is convenient. The method is simple and accurate. The following diagrams will show the connections used:

Fig. 1 shows the voltmeter connected so as to give the potential difference of the supply. Fig. 2 shows the voltmeter connected in series with the high resistance and these two in multiple with the same supply. If these readings are taken very close together and the voltage of the supply is practically constant, we can assume that the potential difference of the supply terminals is in both cases the same. To take a quick reading, connect as in Fig. 2; first, take that reading, then quickly join A and B and the voltmeter will then indicate the potential of the supply.

Let

V = potential of supply.

R = resistance of voltmeter.

x = unknown resistance.

V' = reading of voltmeter in Fig. 2.

C = current flowing in Fig. 2.

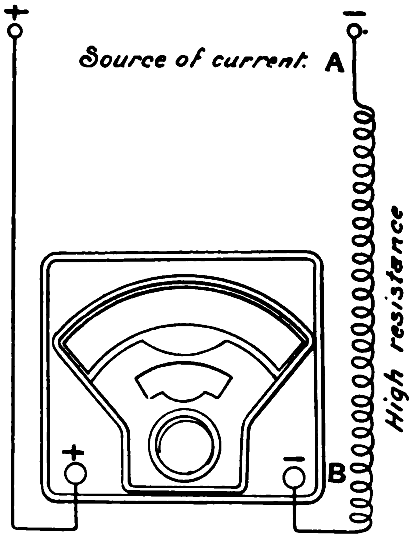


FIG. 2.—CONNECTIONS TO RESISTANCE AND LINE.

Then from Ohm's law we know that the drop in potential in any conductor is equal to the current flowing in that conductor, multiplied by its resistance; so we have

$$V = C(R + x).$$

$$V' = CR.$$

From which we obtain

$$x = R\frac{V - V'}{V'}.$$

This gives the unknown resistance in

[†] American Electrician, June, 1896.

terms of the resistance of the voltmeter and the two voltmeter readings. To take a practical case, we will assume a voltage, V, of 115 volts, a Weston 150-volt voltmeter of 18,000 ohms resistance. In Fig. 2 let the voltmeter read thirty-five volts (V').

Then $X = 18{,}000 \left[\frac{80}{35}\right] = 41{,}000$ ohms.

Where a 500-volt current is convenient, a 600-volt voltmeter will have to be used.

For measuring the insulation resistance of a dynamo or motor in operation, first connect the voltmeter terminals to the machine terminals, thus giving V; then with one terminal of voltmeter connected to one terminal of machine, connect the other voltmeter terminal to frame of machine. This reading is V', then calculate x from formula, which is the insulation resistance.

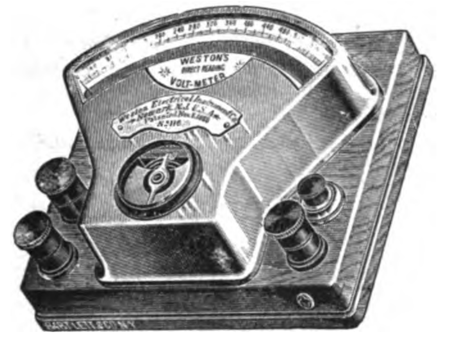


FIG. 3.—TYPE OF VOLTMETER.

For measuring the insulation resistance from the ground of wiring circuits in a building, turn current on wires and measure voltage of mains. Then with one voltmeter terminal connected to one main, connect other voltmeter terminal to a gas or water pipe which gives V'. Then calculate x from formula which gives the resistance of the wiring from the ground. Where an alternating current is the only current convenient, this method can be used, provided the resistance to be measured is non-inductive (that is, introducing no "choking" effect through possessing inductance) and the voltmeter is an alternating current voltmeter whose resistance is known. In case of the Weston instruments, the resistance is carefully measured and marked on the cover of the box containing the instrument.

◆

ELECTROMAGNETIC DEFLECTION OF RIFLE BALLS.

BY W. STUART-SMITH.

Recent reports from Europe give accounts of some experiments by Swiss military authorities to determine the deviation of rifle balls when the line of fire is parallel to a circuit carrying a heavy electrical current. With a view to tracing the effect, trajectory screens were placed at intervals of ten yards along the line of fire, and it was found that in a distance of 260 yds. a rifle bullet took a lateral deviation of twenty-four yards. In experimenting with artillery over a range of 3000 yds. the deviation was 14 degs. The current was conducted parallel to the range and at a distance of forty yards from it.

The explanation of the phenomenon advanced was that the deviation is simply the effect of the action of the magnetic field on the iron. I would suggest that the phenomenon is really much more complicated, particularly if the field is an alternating one. The shot, in its flight through the air, is rotating at a terrific rate about a longitudinal axis, and in a field of variable intensity. Heavy eddy currents will be set up and there will be a tendency not only to move towards the circuit, but to slow down the rate of rotation in accordance with Lenz' law. If the rate of rotation is appreciably lowered the gyroscopic action tending to keep the ball in the same plane will be diminished with the result that it will be more and more easily deflected by a given attractive force. Moreover, the nearer the ball approaches the wire the greater will be the variation of the field on opposite sides of the shot and the more powerful the action. This probably accounts for the fact that the observed deflections were not proportional to the times of flight. If this explanation is correct there should be some deflection in the case of lead bullets owing to the reaction between the field and the eddy currents.

◆

THE METRIC SYSTEM.

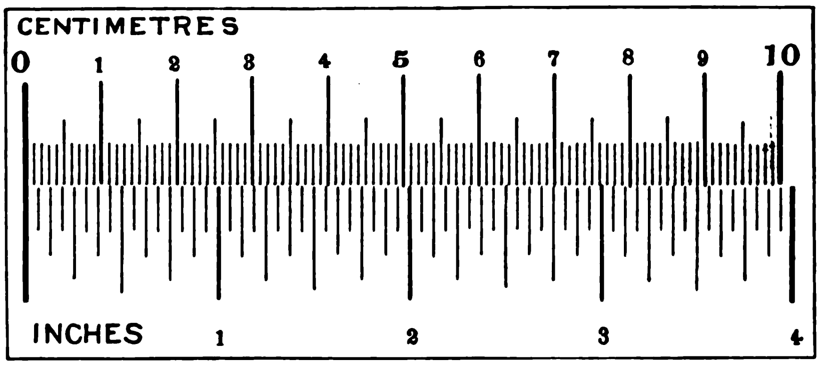
Of the great manufacturing and commercial countries of the world, the United States and Great Britain stand alone in non-acceptance of the metric system of weights and measures. There has, however, been a constantly growing opinion in favor of the adoption of the system, as shown by the report of an English Parliamentary Commission recommending that its use be made compulsory after a comparatively near date, and the narrow escape from passage at the past session of Congress of a bill having similar provisions.

Leaving aside consideration of the relative merits of the English and metric systems, the probable adoption in this conntry of the latter during the present generation, and the fact that all electrical units are based upon it, should be sufficient inducement to those who desire to be rather ahead than behind the times, to obtain a working knowledge of the same. The metric tables in arithmetics taught by rote to children at an age when they cannot seize the significance of the strange names contained therein, have doubtless created with many a prejudice in after life against the system, but its simplicity is such as to make it but a matter of a few hours for a more mature mind to master.

The basis of the system, the metre, is the distance at a given temperature, between two marks on a platinum bar kept at Paris. Although of no practical bearing, it may be added that this particular length was adopted because it was supposed to represent one-forty millionth of a meridian or great circle of the earth, but which, through errors made in the surveys, it does not. The metre, therefore, is no less an empirical standard than the foot, the advantage of the metric system lying entirely in its graduation by tenths and the manner in which different classes of measurements are connected.

The meter is 29.37 ins. in length or 3⅜ ins. greater than a yard (less about 1/100 in.), and replaces the foot and the yard in English measure. The only multiple of the metre used is the kilometre or 1000 metres, *kilo* meaning thousand. The kilometre replaces the English mile in measurement of distance, and is equivalent to 3280 ft. 10 ins. (3280.81 ft.) or 20 ft. less than ⅝ of an English mile. The subdivisions of the metre in use are the centimetre (*centi = tenth*) and millimetre (*milli = thousandth*). The former replaces the English inch, and is short of ⅜ in. by about 1/64 in., being .3937 in. in length. Conversely, the inch is about 2½ centimetres (2.54 centimetres). The millimetre corresponds in use to the sixteenth or thirty-secondth inch; its value (.03937 in.) is very nearly 1/25 in. or 5/128 in. The millimetre is equal to about 39⅓ mils (39.37 mils). The decimetre (*deci = tenth*) is not used. Metre, kilometre, centimetre and millimetre are usually abbreviated m, km, cm and mm, respectively. Accompanying is a reproduction of two scales, one in inches and the other in centimetres, from which it will be seen that 4 centimetres correspond very nearly to 2½ inches.

The measures of area in general use are the square metre and square centimetre, the former replacing the square foot and the latter the square inch. The square metre is very nearly 10¾ sq. ft. (10.76) and the square centimetre between 1/6 sq. in. and 1/7 sq. in. (.155 sq. in.) Conversely, the square foot is between 1/10 and 1/11 of a square metre, or equal to 929 sq. cm., nearly; the square inch is equal to about 6½ sq. cm. (6.45 sq. cm.). The square millimetre, which is rarely used, is about 1½ thousandth sq. in.; or a square inch contains 645 mm^2, nearly. The square metre, square centimetre and square millimetre are usually abbreviated m^2, cm^2, mm^2.



CENTIMETRE AND INCH SCALES.

In measures of volume, the cubic metre and cubic centimetre are used; the cubic decimetre is of interest only because it fixes the value of the litre, which is a measure that will exactly contain one cubic decimetre of liquid. The litre contains slightly more than the American quart, 18 litres being equal to 19 qts. nearly. The cubic metre is about 35⅓ cu. ft. (35.31 cu. ft.). The cubic centimetre is about $\frac{1}{16}$ cu. in. (.061), or a cubic inch is 16$\frac{2}{5}$ cubic centimetres. Cubic metre and cubic centimetre are usually abbreviated m³, cm³

In measures of weight, the gramme is the unit, being the weight of a cubic centimetre of water at a given temperature. The multiple, kilogramme, replaces the pound, and the milligramme is used in fine chemical measurements. Referring to avoirdupois weight, a gramme is equal to $\frac{1}{28}$ oz., nearly, (15.432 grs.), and the kilogramme to 2$\frac{1}{5}$ lbs., nearly, (2.205 lbs.). The milligramme is about $\frac{1}{65}$ gr. (.01543 gr.). The kilogramme is usually abbreviated kgm.

For ordinary practical purposes a knowledge of the English and metric equivalents of the following will suffice, the former being given in the nearest convenient quantity.

Kilometre = ⅝ mile.
Metre = 3 ft. 3⅜ ins.
Centimetre = ⅜ in. (.4in.)
11 metres = 12 yds.
Millimetre = $\frac{1}{25}$ in. (39⅓ mils.)
Litre = 1 qt.
Gramme = $\frac{1}{28}$ oz. (15½ grs.).
Kilogramme = 2$\frac{1}{5}$ lbs.
Square metre = 10¾ sq. ft.
Square centimetre = ⅙ sq. in.
Cubic metre = 1⅓ cu. yd.
Cubic centimetre = $\frac{1}{16}$ cu. in.

Mile = 1.609 kilometres.
Foot = .3048 metre.
Inch = 2.54 centimetres.
1 mil = .0254 millimetre.
Quart = litre.
Ounce = 28.35 grammes.
Pound = 453.6 grammes.
Square foot = 929 square centimetres.
Square inch 6.45 square centimetres.
Cubic foot = .028 cubic metre.
Cubic inch = 16.39 cubic centimetres.

AN OFFICE BUILDING ELECTRICAL INSTALLATION.

An electrical plant installed some time ago by Mr. B. J. Arnold in the Chicago Board of Trade Building is probably the most complete in all of its details of any plant of its kind in the world, and is specially interesting on account of the storage battery equipment and the manner of connection of the steam and electrical generating units. The wiring plan, reproduced herewith and described in detail below, will also be found of interest to electricians.

The installation consists of five 66 in. × 16 ft. horizontal tubular boilers, designed to carry 125 lbs. pressure per square inch; two 150-HP horizontal compound condensing engines running at 575 r. p. m. each directly connected to a 75-KW direct current generator, under a special system which permits either or both generators to be driven from either engine; four horizontal 30-HP Sprague electric elevators; a storage battery of 1000 ampere-hours capacity; six 10-HP electric motors, five of which operate ventilating fans, and one the machinery in the machine shop. On the lighting circuits are 50 2000-CP constant potential arc lamps and 600 16-CP incandescent lamps.

The two engines and generators are equal to the maximum capacity of the plant, and the storage battery to one-third its capacity. When the battery is operating, one engine unit in conjunction with it handles the plant economically and satisfactory, leaving one engine unit in reserve. In case the battery is out of service, both units can be operated until the battery is ready for service again, and during the light load period the battery auxiliary takes care of the entire service of the building, without the use of either engine or generator units. The system, when used without the battery auxiliary, is provided with magnetic clutches, which permit the generators to be brought up to speed as motors, and thrown in connection with the engines without stopping either engine. This makes it possible to connect either generator with either engine without shutting down the plant in any part.

From 11 P. M. until 7 A. M., the entire load of the plant is operated by the batteries alone. With this arrangement but two shifts of labor are required, one operating from 7 A. M. until 3 P. M., and the other from 3 P. M. until 11 P. M. From 11 P. M. until morning during the winter, the watchman acts as fireman for the boilers to maintain the steam heat in the building.

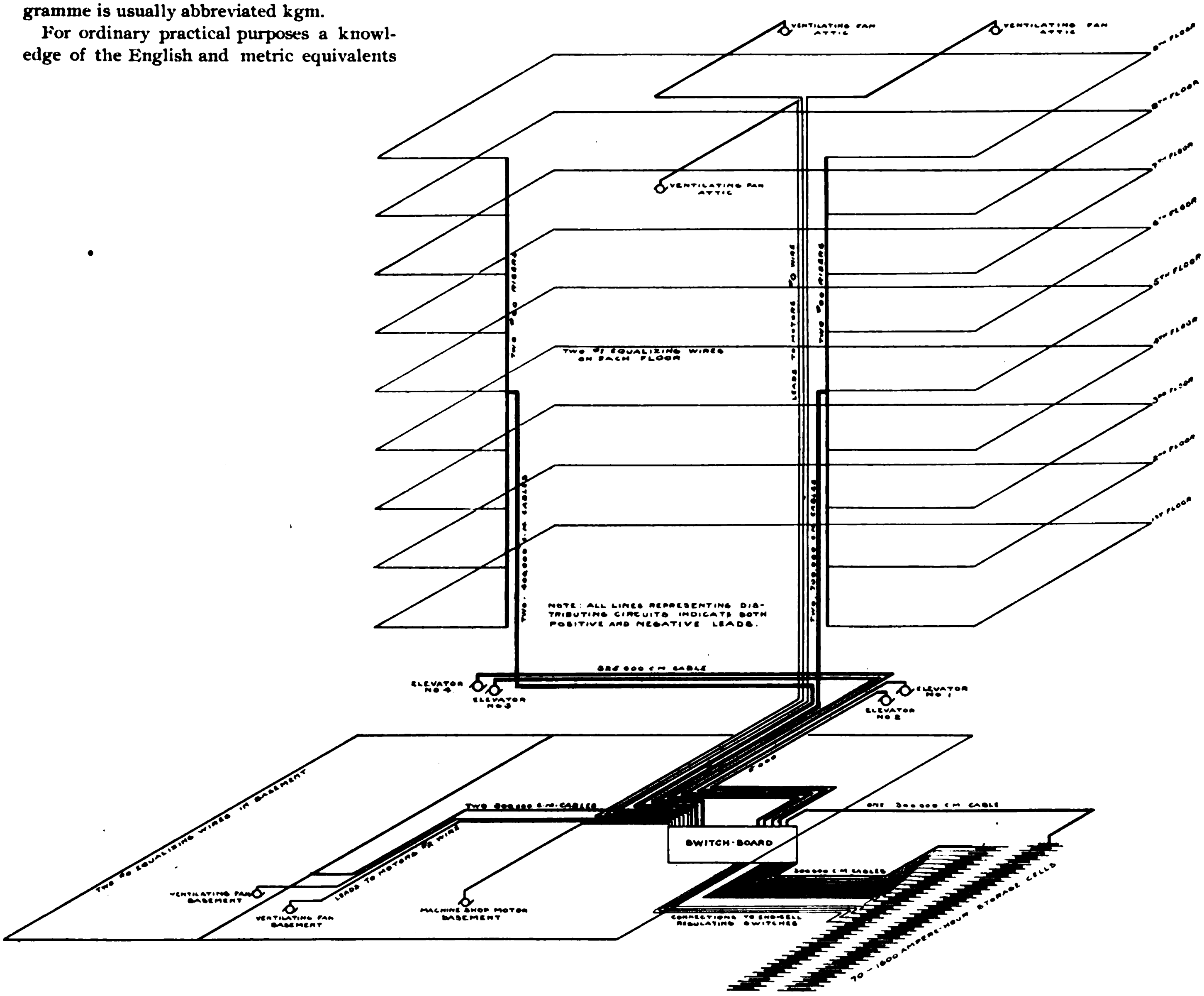


DIAGRAM OF CIRCUITS OF OFFICE BUILDING.

The shunt and series field windings of the generators are so connected as to enable either the elevators to be run without the batteries, or to throw the generators and batteries in parallel on the elevator load. In the former case the compound winding is used, and in the latter only the shunt winding, the series coil being then cut out.

Under normal conditions the elevators are run with the battery and generators in parallel. By means of a hand regulator, the operator cuts in a sufficient number of cells in parallel with the generator, so that the cells are constantly charging during the time of operation of the elevators, except at temporary moments of excessive demand for current from elevator overloads. When this pull from the elevator occurs, the batteries respond and take the surplus load from the generator. With this arrangement, about fifty of the cells are kept constantly charged, and in parallel with the elevators. In case the amount of current entering the cells is excessive between the intervals of heavy load on the elevators, the hand regulator is adjusted so as to cut in one or more cells until the current becomes reduced to the proper amount for the batteries; and, on the other hand, if the amount entering the cells is not enough to keep them properly charged, the hand regulator is adjusted so as to cut out a number of cells until the proper amount of current is reached. In the meantime, if the fifteen end cells require charging, they are charged by means of a Bernard booster or motor-generator.

The accompanying illustration represents diagrammatically the wiring plan of the building. The system employed was adopted for the reason that the building has two main flues or passageways extending from the basement to the attic, in opposite portions of the building and near its centers, thus being available for carrying the main risers. It was decided to place in these passageways vertical risers of sufficient carrying capacity to carry the total amount of energy required for the nine floors, and to join the floor leads or secondary mains to each of these risers at its ends. With this arrangement it is possible to feed the secondary mains at two independent points, thus equalizing the pressure to better advantage and making the plant more reliable in operation.

From the center of these vertical risers, or at about the fifth floor, the main leads drop down each shaft, thence extend horizontally on the ceiling of the basement to the switchboard. Each of the mains leading to the center of distribution in each shaft are of sufficient capacity to carry the total load of the building, exclusive of the basement; consequently, if a fuse blows on either one of the mains, or if by any accident any one of the mains should become broken or opened, the other main will carry the necessary current and keep the lights operating in the building. This precaution was taken owing to the fact that business matters of great importance are transacted in the building, and the loss of a few minutes at certain times might be disastrous.

The basement circuit is independent of the above described mains, and consists of positive and negative leads, surrounding the entire basement of the building, from which are tapped the arc and incandescent lights used in the basement. The motor circuits are clearly indicated in the diagram, and are independent of the lighting circuits, and so planned that the starting rheostats of the motors are connected on the switchboard under the control of the engineer, thus making it possible for the engineer to start or stop any motor in the building without leaving the switchboard. The elevator circuits are also independent of the lighting and motor circuits, and it is possible to throw the current on or off any elevator at the switchboard. The batteries are located in a room adjoining the main engine room, and are connected with the switchboard as shown on the diagram.

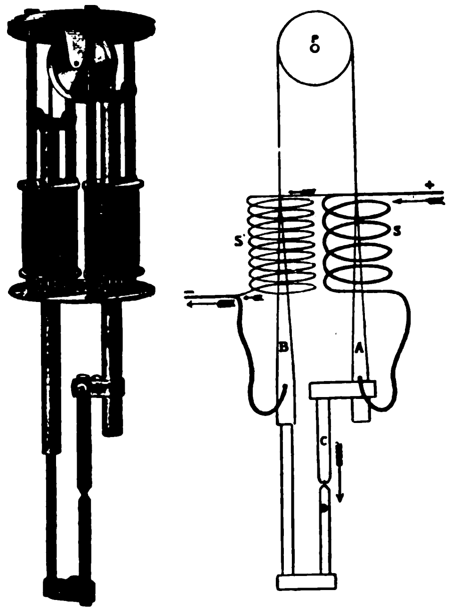
The losses in wiring circuits of the building were computed as follows: Between generator and switchboard, one-half of one per cent.; between switchboard and center of distribution, 2½ per cent.; from center of distribution to secondary mains, one per cent.; between secondary mains and lights, one per cent.—making the total loss between generator terminals and lights five per cent.

◆

THE PILSEN ARC LAMP.

How simple it is possible to make the mechanism of an arc lamp is shown by the accompanying illustrations, representing the Pilsen lamp, which has been in successful commercial use in Europe for twelve years or more.

The mechanism consists simply of two soft iron conical cores, *A* and *B*, suspended by a flexible cord from a pulley, *P*, and carrying the carbons, *C* and *D*. The combination thus constitutes a balance, and regulation is secured by means of the conical cores, one of which plays in a series solenoid and the other in a shunt solenoid. The arc itself is maintained in a fixed position by using an upper carbon of twice the sectional area of the lower carbon; that is, if the lower carbon is $\frac{7}{16}$ in. in diameter, the upper is ⅝ in. As will be seen from Fig. 1, the conical cores are encased in cylindrical tubes. The operation of the lamp is as follows :



PILSEN ARC LAMP.

When the lamp is cut in, the two carbons being in contact, the greater part of current passes through the series solenoid, *S*, which attracts its core, *A*, thus separating the carbons and striking the arc. If, from any cause whatever, the two carbons are not in contact at the moment when the lamp is cut in, all of the current will pass through the shunt coil, S^1; the core, *B*, will then be attracted, the core, *A*, lowered, and contact thus made.

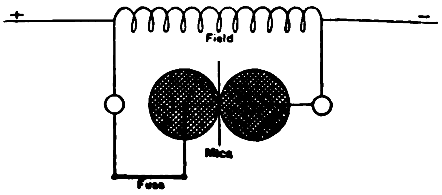
The windings of the solenoids are so calculated that the attraction exerted on the respective cores is equal when the current is normal, and corresponding to a normal length of arc. Under these conditions the two cores are balanced as long as the arc remains normal.

When, through the carbons becoming used, the arc lengthens, its resistance increases and, of course, the current in the series solenoid, *S*, decreases; consequently, the core, *A*, being less attracted, tends to descend. At the same time, the current passing through the shunt solenoid, S^1, increases in strength on account of the increased resistance of the arc, and the core, *B*, is attracted—the result being that the carbons are approached and the arc again a normal length.

◆

Dynamo-Field Safety Device.

The accompanying illustration represents a device for preventing damage to dynamo field coils through the high potential which is induced in such coils if the field circuit is suddenly interrupted. As shown, the device is connected as a shunt to the field circuit, and consists of two carbon disks mounted side by side on a slate base. The disks are pressed toward each other by springs, and between them is interposed a strip of mica of suitably adjusted thickness which, not being as wide as the faces of the disks, leaves a small air space between them. A safety fuse is provided which, in case of a permanent circuit being established between the disks, will blow and thus prevent a short circuiting. The disks can be turned on their axes so as to present towards each other fresh portions of their peripheries, which are cleaned by metal scrapers that bear against them. If a field circuit of a dynamo provided with this device is broken, accidentally or otherwise, the difference of potential created at its terminals will rise to an amount sufficient to produce a spark between the two disks, and this spark will last until the field has gradually died down. When the field circuit of large multipolar machines or alternators is broken, it is stated that the spark is seen to last as long as twenty to thirty seconds. The above description of the device, which is the invention of Messrs. W. C. Johnson and L. J. Steel, is extracted from the London *Electrician*.



DYNAMO-FIELD SAFETY DEVICE.

NOTES.

Mathematics and Theory.—In a recent article Prof. Oliver Heaviside says that in only one respect is the subject of "Dispersion" easy—it is perfectly easy to make a mathematical theory of it or twenty theories in an hour, if desired. But it is not easy, he adds, to make a mathematical theory which shall agree with the facts, which are rather complicated, and vary from one body to another; and, as for physical theory, the case is worse still.

A Compliment Resented.—Our English contemporary, *Lightning*, quotes as follows: "It is useless to deny that America has much to learn from Europe in the matter of the business management of municipalities" and then proceeds in this strain: "Mayors, corporations, and municipal magnates generally! the above words are taken from the latest issue of one of the most important representatives of American technical journalism, which goes on to say that even mayors—mayors, mind you!—are selected from among those 'who have not only proven themselves good men of business, but who are fitted by special experience for the position they occupy.' Worshipfuls of the fur-trimmed gown and golden chain! think of this encomium, and try to live up to it. We know not whether the rash prophet of truth (?) who penned those fateful lines still survives, or whether ere this the fell swoop of American spread-eagleism has fallen upon him and rended him with beak and claw as a truckler to the effete monarchies of the old world."

Electrolytic Corrosion.—Prof. Wilbur M. Stine in a letter printed in a report of the Electrical Bureau of the National Board of Fire Underwriters, describes the destructive effects of electrolytic corrosion on the piping of a plant installed for supplying light and power to a large building. Special pains had been taken to make the engine room ornamental, and a portion of the drip piping from the engine and heating apparatus was buried under the marble floor of the engine room. The main leads from the switchboard were run in a wooden conduit under a cemented floor to a fuse closet. Soon after operating the plant, these buried leads developed a leak, which amounted to two amperes by measurement. The dynamos were thoroughly insulated by dry wooden bases resting on the marble floor, but the underlying sand is generally water-soaked, and in a short time the buried steam piping grew so defective that it was taken up. Nearly all the pipes showed evidences of extensive electrolytic decay, and in some cases large holes were eaten entirely through the walls of the pipes.

The Annual Electrical Clambake.—First instituted, eighteen years ago, when the telephone had not yet entered the commercial stage, and arc lighting was yet scarcely more than an experiment; at whose earlier gathering, doubtless, the knowing winked at the inside information imparted concerning a singular lamp which was said to solve the problem of the sub-division of the electric light, or later smiled at predictions made as to the feasibility of electric traction or the long distance transmission of power—the annual Rhode Island clambake of the American Electrical Works has witnessed the growth of the electrical industry from its veriest beginnings, and has become a cherished event in the electrical calendar. The eighteenth gathering, at the Ponham Club, near Providence, on Aug. 22, was attended by several hundred guests, and was a success in every respect. Among those who responded to toasts were Messrs. Thos. D. Lockwood. Herbert B. Cram, Capt. Wm. Brophy, Robt. F. Ross and Col. J. C. Wyman. At the close of the festivities, the presiding genius, Mr. Eugene Phillips, was, for the eighteenth time, voted an incomparable host.

Electricity in Coal Mining.—In a paper entitled "Economies in Coal Mining," read before a joint meeting at Pittsburgh of the Western Pennsylvania Central Mining Institute and the Ohio Institute of Mining Engineers, Mr. Cyrus Robinson stated that in his experience he had found that wherever electricity has been adopted as a means for the transmission of power in a coal mine, its use has been gradually extended to all parts where power is required, every addition increasing the economy by decreasing the fixed charges on the balance of the operations. In plants where an electric system of haulage has been installed, Mr. Robinson has noticed that by degrees the system has been extended for the purpose of running the fans, pumps, screens and coal cutting machines from the same plant. With the electric system in general use for haulage, coal cutting,pumping, etc., the greatest total economy is effected, and where the mine is free from gas and the roof ordinarily good, it does not require a very extended investigation to prove the advantage and economy of of electricity over all other systems of power transmission for the coal mine. A table was given of the cost of wire and pipe installed, based on the current market price of material and labor, showing very conclusively the superiority and economy of the electric system of transmission as compared with the pneumatic.

Li Hung Chang and Electricity.—The latter part of the visit of the great Chinese viceroy to the United States was enlivened by two electrical episodes. What actually happened at the Niagara power house, the scene of one, it is difficult to exactly determine from the newspaper accounts. According to the press dispatches, the inquisitive statesman touched one of the great generators with a cane, which resulted in a brilliant pyrotechnic display and a shock that wrenched the cane from the hand of the startled viceroy—though why this should have followed from touching a field magnet with a non-conductor is not clear. The accounts of the other episode, which are inexplicably involved, relate to the relations of Col. Gouraad, of telephone fame, with the viceroy. According to one report, the gallant colonel,profusely decorated with medals, upon entering the presence of Li Hung Chang dropped upon his knees and kissed the hand of the astonished oriental, who, the story goes, was far from relishing this knightly courtesy. Another tale relates that Col. Gouraad took offense at a remark made by Li Hung Chang, and after giving the Chinaman "a piece of his mind," retired from his presence in dignified order. Still another story, for which the colonel himself is authority, tells of hours of conference between the two great men, which resulted in Li Hung Chang engaging the remaining years of Col. Gouraad's life in the interest of a project, the details of which have not been confided to the public.

Franklin as a Practical Man.—The characteristic of Benjamin Franklin's genius which stands out in greatest relief, and to which his fame is mostly due, is its intensely practical nature. As soon as he took up the study of electricity its practical application was a subject ever present in his mind, and the year before he established the principles of the lightning rod and thus made the first practical application of electrical knowledge, he expressed chagrin that "We have been hitherto able to produce nothing in this way of use to mankind." Some time before this the news had reached America of Watson's experiment of firing alcohol on one bank of the Thames by means of an electrical discharge from a Leyden jar on the other bank, and Franklin proposed to repeat the experiment in the following characteristic practical manner: "It is proposed to put an end to [experiments] for this season, somewhat humorously, in a party on the banks of the Schuylkill. Spirits, at the same time, are to be fired by a spark sent from side to side through the river, without any other conductor than the water. A turkey is to be killed for our dinner by the electrical shock, and roasted by the electrical jack, before a fire kindled by the electrical bottle; when the healths of all-famous electricians in England, Holland, France and Germany are to be drunk in electrified bumpers, under the discharge of guns from the electrical battery."

Are Electrical Manufacturers Illiberal in Spirit?—In the *American Machinist*, Mr. R. D. Williams endorses a statement made that electrical engineers and manufacturers are "among the most narrow minded men in the world." The charge is based upon an alleged spirit of illiberality on the part of those connected with the electrical industry in jealously guarding professional and shop experience that in other professions is freely published in a spirit of mutual helpfulness. Hints and experience of great value, it is stated, are freely given in the columns of the mechanical journals, while an examination of the files of the electrical journals show that the *American Machinist* alone contains five times as much matter of this type as is contained in all of the latter. Mr. Williams concludes as follows: "Education is supposed to have a broadening effect on the mind; in fact, in the eye of many educators this is its chief aim and purpose. What sort of evidence in support of this proposition does the condition of the electrical industry give? The great majority of leading mechanical men have come up from the ranks, and, whether that condition continues for the future or not, the present spirit of mutual helpfulness which characterizes mechanical men was established by those of little or no formal education. The spirit which characterizes the electrical industry was, on the contrary, established by educated men, and the contrast is not one of which education can be proud."

Municipal Electric Lighting Statistics.—The agitation in favor of municipal electric lighting plants is, in many instances carried on by demagogues, who usually indulge in gross misrepresentations as to the economy to be achieved under municipal management. In many instances the private owner of a central station plant which it is proposed to dispossess through the establishment of a municipal plant is thus put in the position of a grasping monopolist charging the community extortionate prices, and in the lack of the necessary statistics he is defenceless. At the July meeting of the Northwestern Electrical Association, a committee was appointed to gather statistics as to the actual cost, including fixed charges, etc., of generating current in central stations, both private and municipal, which work is now under way. The electrical public can greatly aid in this praiseworthy undertaking by furnishing data gathered in their respective localities, and particularly data relating to municipal plants. The public reports of the latter are generally valueless on account of the omission of any statement whereby the fixed charges, taxes, etc., may be estimated, and through the custom of providing for extraordinary expenses by special appropriations and charging parts of salaries, etc., to other departments. Mr. Henry L. Doherty, general manager of the Madison Gas & Electric Company, Madison, Wis., is chairman of the committee above referred to, and will be pleased to enter into communication with any of our readers who may be willing to aid the work by supplying statistics relating to the communities in which they live.

Conservation of Energy. In a notice of the work of the late Sir William Grove, the inventor of the Grove voltaic cell and of the gas battery, the London *Engineer* says, in referring to the doctrine of conservation of energy, of which Grove was one of the founders, that "There is but one fundamental deduction that can be drawn. All the phenomena that we can see and feel, and think of as possible, are forms or modes of motion. This is the fundamental concept of the conservation of energy, which means neither more nor less than the conservation of motion. There is really no escape from this deduction. It is true that certain teachers, hesitating to accept the inevitable, have adopted the phrase 'potential energy' to express a condition that they do not understand; a phrase fatal for all practical purposes to the doctrine of the conservation of energy, which, from the standing of an established fact, is reduced by it to the position of a metaphysical speculation; for, to take an example, when a stone was raised to the top of one of the pyramids, energy was expended and lost, not to be returned for, it may be, hundreds of thousands of years. The truth all the while is that there is no energy stored in the stone. The work of lifting it was done on gravity, and in gravity, not in the stone, we must seek for the energy so expended. The great work done by Grove was in all respects akin to that of Helmholtz. Attempts have been made now to give the credit of priority to the one, now to the other. A vain thing, a waste of argument much to be deprecated. Let us rather regard them in the light of co-workers, each with the same lesson to teach, but teaching it in a different way."

American Association for the Advancement of Science.—At the forty-fifth meeting of the American Association for the Advancement of Science, held at Buffalo during the week beginning Aug. 24, a number of papers were read on subjects relating to electricity and mechanical engineering, among which were the following: The Most Economical Points of Cut-Off for Steam, by Henry T. Eddy; The Performance of Small Steam Pumps, by M. E. Cooley; On a Continuous Indicator for Engine Tests, by Thomas Gray; Apparatus for Observing the Distribution of Moisture in a Steam Main, by D. S. Jacobus; An Arrangement for Using Storage Batteries for the Automatic Regulation of Engine Loads in Power Plants of Variable Output, by W. S. Franklin; On the Effect of Odd Harmonics Upon the Virtual Values of Periodically Varying Quantities, by Dr. Frederick Bedell; Electrical Waves in Long Parallel Wires, by A. D. Cole; Graphical Treatment of Alternating Currents in Branching Circuits, by Henry T. Eddy; On the Counter E. M. F. of the Electric Arc, by W. S. Franklin; Some Points in the Mechanical Conception of the Electromagnetic Field, by W. S. Franklin; A Theory of Galvanic Polarization, by W. S. Franklin and L. B. Spinney; On the Rule for the Dynamo and Motor, by Alexander Macfarlane; On the Distribution of High-Frequency Alternating Currents Throughout the Cross-Section of a Wire, by Ernest Merritt; An Experimental Study of the Charging and Discharging of Condensers, by F. E. Miller; The Influence of a Static Charge of Electricity on the Surface Tension of Water, by Edward L. Nichols and John Anson Clark; A New Alternating Current Curve-Tracer, by Edward B. Rosa; Preliminary Note on a Proposed New Standard of Light, by Clayton H. Sharp; Note on the Duration of the X-Ray Discharge in Crookes Tubes, by Benjamin F. Thomas; Electrolysis and Some Outstanding Problems in Molecular Dynamics, by C. L. Mees; Polarization and Resistance of a Galvanic Cell, by B. E. Moore; Photographic Study of Röntgen Rays, by W. A. Rogers; Mechanical Model of the Electric Circuit, by Brown Ayres; Portable Apparatus for Recording Curves of Alternating Current and E. M. F., by H. J. Hotchkiss.

Tesla as a Seer.—The following curious extract is from an interview by a New York *Herald* reporter with Mr. Nikola Tesla, the subject of the interview being "the transmission of sight by wires or otherwise." After stating that he had arrived at a few precise facts bearing on that problem, but yet enough to make an approximate estimate of all the elements involved in a practical demonstration, Mr. Tesla says "Have you ever abandoned yourself to the raptures of the contemplation of a world you yourself create? You want a palace, and there it stands, built by architects finer than Michael Angelo—aye, even finer than if by my friends McKim, Mead & White. You fill it with marvelous paintings and statuary and all kinds of objects of art. You summon fairies if you are fond of them. Now, perhaps, you want to sit on a throne, and there is your throne, greater than that of Great Britain! And all your subjects are around you—countless subjects. No fellows to run after you with a pistol, as fellows do after illustrious personages, like William and Nicholas or Li Hung Chang. And if they would, what do you care? You stop their bullets in midair. Now you walk out in the streets of a wonderful city. Perchance it is one of my cities. Then you may see that all the streets and halls are lighted by my beautiful phosphorescent tubes, that all the elevated railroads are propelled by my motors, that all the traction companies' trolleys are under ground and supplied by my system, and that all the currents are supplied by my oscillators, or else that my friends of the Cataract Construction Company are transmitting all the power by my system from a far-off Niagara. And now, perhaps, you meet a tramp in the street, and you reach in your pocket and give him something. Five cents, you think. No, sir; you give him not less than $5,000,000.

"Strangely, though, instead of collapsing at your generosity, he looks at you in an insolent way and turns the money in his hand and says, contemptuously:—'Take it back you mean skinflint.' And then you throw down your royal insignia and you begin to grapple with him. You are endowed with giant strength, and he is no fellow to fool with, either. At any rate, the issue is uncertain. He may be stronger, and then, well—then you wake up, saved, but badly used up. If you defeat him, then you recompense him royally by giving him your insignia and your throne, and you continue your adventurous voyage peacefully and contented.

"Suddenly you throw yourself in the roar of a battle, you cut and slash, and a whole army of noble knights flees before you. And now something rattles in the bushes, and you, who know no fear, you run away. Then you may witness a terribly impressive scene of years gone by. You witness the death of your father or your mother, and you go through all the agonies again. You realize the immense gulf that separates you from them. Then overwhelming desire takes hold of you to be with them again. You know it is impossible to get them back; but never mind, you will invent something, you will discover some force which will reunite those separated molecules and make them form those lovely shapes so dear to you.

"And now suddenly there comes a revulsion, and you are throwing a stick at a cat in a backyard. You miss it, too—aggravating circumstance. But years afterwards you can tell the exact spot on the wall, you can tell every mark of the stick, and you see exactly how the cat's fur was brushed one or the other way. So your imagination leads you on, from sorrow to joy, from work to play, and all this world is ever present, ever ready for your pleasure and enlightenment, and at your wish and command. All this world, real or imaginary, it matters little, you want to be able to see through some such thing as a wire, for if you succeed in transmitting sight you will see it all."

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Induction Motors.

One of the supposed drawbacks to the induction or polyphased motor which has been urged, is its inability to appreciably vary in speed. In another column Mr. P. M. Heldt shows that the speed of such motors may be varied through wide limits, and that, as comparedto the shunt motor, it possesses an advantage in this respect. A number of methods are described for producing variation of speed. Tests have shown that by means of one of these the speed may be reduced to one-fourth of its highest value without much sacrifice in output and efficiency. In this case four different speeds are possible, ranging from 2650 revolutions with an efficiency of 77 per cent., to 640 revolutions with an efficiency of 70 per cent. The reduction of speed is, however, abrupt, but by combining one of the other methods described, some gradation may be obtained. Mr. Heldt also points out another advantage of the induction over the shunt motor, consisting in its ability to carry an overload with much less heating. It seems probable that as the polyphased motor enters into greater use, it will be found to answer all of the purposes to which continuous current motors are now applied. Some years ago Dr. Bell pointed out that this motor is not inferior to the series motor with respect to variation in speed, and that while the efficiency is low at low speeds, it is not less so than the series motor. That the polyphased motor is now used for street railway work with success (at Lugano, Switzerland), is evidence of its flexibility of action.

◆

Dynamo Brushes.

The article in another column by Mr. A. E. Wiener, on the selection of dynamo brushes, their proper contact area and commutator pressure, contains, we believe, the most complete consideration from the practical standpoint of the subjects treated that has yet appeared in print. Heretofore, much of the information on these points has been of the indefinite kind which is useless to both the theoretical and practical man. What the latter wants are precise statements that will enable him to determine numerically the exact data for a given machine; what he is usually offered are discussions on the theory of sparking, etc., and told that if the pressure of the brush on the commutator is too great there will be cutting, while if too small there will be sparking, and so on. The article elsewhere in this issue, on the other hand, gives formulas by means of which the cross-sections of brushes and commutator pressure may be simply calculated for any given condition, the results being expressed in square inches and pounds, and requiring a mere knowledge of arithmetic for their application. To illustrate the application of the formulas numerical examples are given under each.

Usually dynamo brushes are selected haphazard and adjusted entirely by guess. The advisability of following rules based upon proper principles is evident from the fact, that one of the chief causes of sparking and of undue heating of the commutators of even well designed dynamos, may be traced to the improper selection and adjustment of dynamo brushes. In Mr. Wiener's article it is shown that by properly adjusting the resistance of a brush, its contact area and its tension, both the sparking and heating of the commutator—the latter an evidence of excessive energy waste—can be reduced to a minimum, and the simplicity of the formulas for this purpose places their use within reach of all.

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Indicator Cards.

The engineer who has come into contact with so-called "theory" in connection with indicator cards alone, is entirely justified in holding the word "theory" in contempt. In no department has the word been more abused by its use in an entirely unwarranted sense. With "theoretical" forms of cards whose every line is at variance with theory; with "theoretical" expansion lines based upon assumptions contrary to the most elementary theory of the action of steam; he indeed has cause to have a grudge against the word. As we have shown elsewhere, the constructions offered by writers on the steam engine indicator card for determining the point of cut-off and clearance violate the simplest principles of steam working, and give extraordinarily incorrect results if applied to the card of the ordinary engine. The same is true of the method of determining valve and piston leakage, which has the further disadvantage of showing an engine to be most efficient and in good order when its valve may be leaking like a sieve.

It is sometimes said that in writing for the practical man, methods, processes, etc., should be described without accompanying reasons, as he is only interested in results. We believe this to be an entirely unwarranted assumption, and little creditable to the readers of those who follow it. It has apparently, however, been accepted by most writers on the indicator card, and with results that might be expected. For, if instead of laying down a method without explanation of the assumption upon which it is based, the principles were also given, the practical knowlege of the reader would at once teach him the limitations of the method, and incidentally the difference between theory in its proper sense and "theory" used in the sense of a mere assumption, the latter frequently grossly unjustified.

In conclusion, it may be said that the only theoretical indicator card or expansion line is that traced by an indicator on an actual engine. It is useful sometimes to draw a card or expansion line conforming to certain assumed or perfect conditions of steam working, but such constructions should be called "ideal" rather than theoretical ones. The former word is used in this sense by authoritative writers on the steam engine, and should enter more largely into the language of the practical man.

◆

The Test of Practice.

In attempting to decide upon the actual practical importance of a new discovery or application, one is apt to tread upon dangerous ground. Even with all of the facts at hand involved in the practical working of a new principle, it is difficult to predicate in regard to its commercial success, for the reason that the commercial factors, unlike the scientific ones, are subject to all manner of modifications and even to reversals of significance, while time may introduce new ones of predominating importance.

Doubtless several illustrations of the above statements will occur to the reader, and the case of alternating current distribution may be mentioned. In the early days of alternating current distribution it happened—in this instance fortunately—that little or nothing was generally known of line inductance and transformer losses. Had theory preceded practice, it is quite probable that alternating current distribution would have been looked upon with disfavor, and many calculations made to show that it was most seriously lacking in the elements of regulation and efficiency on account of the drop due to the inductance of the distributing system and transformer, and the energy losses in the latter. Knowing nothing about these factors, the system went into general use and demonstrated its entire practicability before theory could point out its inherent defects.

Perhaps the favorable results achieved in the case of alternating current lighting has had its effect on those who otherwise would point out and insist upon the defects of long distance transmission of power. It is true that the advocates of the several rival polyphased systems have each attempted to show that lack of balance between the circuits of the other systems than his own is a serious disqualification, but these arguments, being frankly commercial ones, have carried little weight. Line inductance has also been somewhat discussed, but no definitely unfavorable conclusion advanced. That there is reason for care in this latter respect was shown by a recent instance. A company about to put in an extensive underground polyphased system was warned that the variation in voltage would be so large as to render proper regulation out of question. Upon a guarantee received from the company installing the system, the plant was laid down, and when in operation showed, instead of a variation of 15 or 20 per cent. as predicted, only about the same amount that would have been present if the continuous current had been used. The discrepancy between theory and practice in this case was due to the former taking no account of the influence of the lead casing of the cables used. Eddy currents set up in this casing, it seems, almost entirely nullified the impedance effect, and with an accompanying energy loss that was insignificant. It might be added that this action has been known for several years in the electrical department of the U. S. Lighthouse Board, and advantage taken of it in cable work for buoy lighting.

What has been written does not, however, furnish an argument for those who accept any and every new discovery or application as full of promise until actually proved by practice to be otherwise. As stated before, the scientific factors are definite ones. In some instances, of course, they are only partially known, and in cases are not sufficiently strong to justify neglect of possible future commercial conditions; they nevertheless cannot be dismissed with a slur at theory and references to what Lardner is falsely credited with having said as to the impossibility of transatlantic steam navigation. The conservatism of the scientific man in these days of independent investigation and freedom from the trammels of authority, has in it little or nothing inimical to progress. On the other hand, the optimistic spirit which sees wonders in everything that is new, merely because it is new, confounds the good with the bad to the disadvantage of the former. The unfavorable effect of a scientific conclusion is corrected the instant an error in the conclusion is shown, while the public, deceived by all manner of optimistic assertions, is apt to retain its unfavorable opinion of a project which did not in its early stage realize wild predictions, though later it may have developed into real though prosaic value.

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Municipal Ownership.

The sentiment in favor of municipal ownership seems to be rapidly spreading, particularly in the West, in which section also but little, if any, mercy is shown to the owner of an electric lighting plant where the doctrine is put into practical execution. The menace is greatest toward the owners of plants in small towns, for in the larger cities the companies are better able, both from the technical and financial standpoints, to defend themselves. Besides, in large cities the voters are less likely to be greatly interested in favor of the policy of municipal ownership.

Much has been said in condemnation of manufacturers of electrical machinery, whose agents are accused of giving aid in many cases to the advocates of municipal ownership in order to make sales. Such practices, of course, are entirely indefensible on the part of manufacturers, whose duty it is to discountenance and not encourage attacks on individual members of the interest which as a whole furnishes their principal, or, in some cases, their entire support. On the other hand, it must be recognized that in certain sections of the country a sincere belief exists in the principle of municipal ownership, and therefore the real issue is not met by waging war on manufacturers.

What appears to be the best plan for the emergency is one which will recognize the honesty and sincerity of those who advocate municipal ownership, and direct all endeavors to showing that, however well founded that principle may be, its practical application will entail greater expense on a community than electrical supply by private enterprise. In the past considerable harm has undoubtedly resulted from the vituperative character of much of the writing by champions of private ownership. No good can possibly result from violent attacks upon the motives of those favoring the idea of municipal ownership, and even economic arguments will have little or no force with a great part of the audience which it is desired to influence. What is rather required is the presentation of facts and figures relating to actual municipal plants, accompanied by a plain and dispassionate analysis setting forth their bearing—leaving it to the reader to weigh his theories against the almost necessarily unfavorable facts thus presented, and to draw his own conclusions as to the motives of those urging the measure under consideration.

Such statistics as are necessary for this purpose cannot be easily obtained by perfunctory correspondence and requests to fill in forms. What is required to be known are the total outlay on a given plant from its inception, the tax, depreciation and other charges often disregarded in municipal book-keeping, the manner in which a plant is keeping pace with modern developments, and the extent of its patronage by the community as compared with private plants in other communities of similar character. It will readily be seen that the compilation of such statistics will not be a matter of mere correspondence, but, on the contrary, will require personal investigation and entail considerable expense. Once obtained, however, such information will be of great value, whereas, with scarcely an exception, the statistics heretofore compiled are almost, if not entirely, useless for the purpose here outlined.

A CONDENSER FOR EXTREMELY HIGH POTENTIALS.

A condenser for high potentials that is commercial has been a problem that has long defied complete solution, and the demand for one that will withstand the enormous potentials of so-called Tesla currents, has been only partially met by the clumsy and ineffective Leyden jar. The writer's practical experience with the condenser herein described bears him out in offering it as a complete solution for Tesla currents as usually employed, and a partial solution for the problem of how to get a condenser for high voltage commercial currents.

This condenser has a capacity of about .02 microfarad according to the specific inductive capacity and thickness of the glass that is used. It will replace a battery of fifty or sixty quart Leyden jars and will only occupy the space of a couple of them. If it is stacked in banks of fifty or sixty, a capacity of one microfarad could be obtained, which is sufficient for experimentation on commercial circuits. This condenser can be made by the veriest amateur, at an expense not exceeding $2.50.

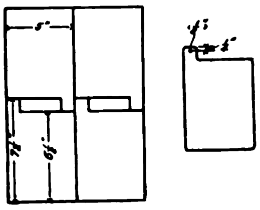


FIG. 1.—GLASS PLATES.

Procure of some good-natured photographer a supply of old negatives five by seven inches in lateral dimensions. About one hundred will be needed. Soak them in hot water till the gelatine film has dissolved, rinse them off, and when dry and clean they are ready for use.

A dealer in photographic supplies will sell ferrotype plates 14 ins. × 10 ins. for not more than four cents each. As each plate of this size will make four condenser plates, the total cost of the latter will not exceed $1. The plates should be laid out and cut as shown in Fig. 1. Through the center of each lug should be drilled a ⅛ in. hole. Procure an Edison-Lalande jar 5 ins. × 8 ins. in horizontal sectional dimension, this being a standard size. Select the jar with some care, being sure that the bottom and sides are perfectly flat, for otherwise the condenser plates will not pack in place nicely. Two pieces of ⅛ in. brass rod should now be obtained, together with a box of ⅛ in. copper rivet burrs, and some ⅛ in. standard tap brass nuts. The brass rods should be the length of the Edison-Lalande cell, and should be threaded for some distance on each end. Having obtained about one-half gallon of paraffine oil, the condenser is ready to be put together.

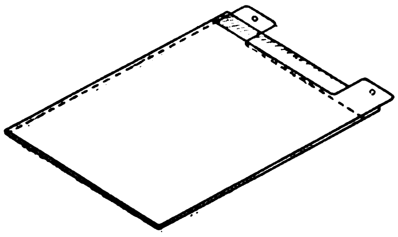


FIG. 2.—ARRANGEMENT OF PLATES.

The first thing to do is to pack the jar full of glass and ferrotype plates, so adjusting their number that there will be one less ferrotype than glass plate. If the glass is not too thick, the jar will hold between ninety and one hundred plates, and it should have just enough that the walls of the jar shall be effective in holding the plates together in a solid homogeneous mass.

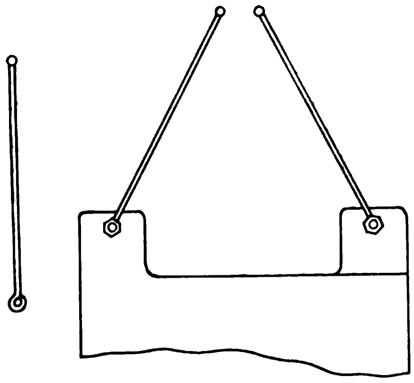


FIG. 3.—TERMINALS OF PLATES.

The plates of glass and sheet iron should now be arranged alternately, as shown in Fig. 2. The lugs of each set of plates are to be threaded with the brass rods before mentioned, and rivet burrs interspersed so that when the nuts are set up as shown in the sketch of the complete condenser (Fig. 4) the tin plates will not bind the glass plates between them. The terminals may be simple wires, but preferably a ball and knob arrangement as shown in detail in Fig. 3, and in position on the condenser in Fig. 4. After the condenser is thus arranged, it remains to fill it up over the tops of the lugs with paraffine oil and it is complete.

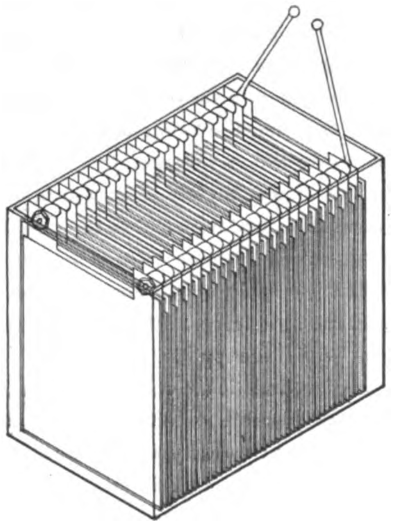


FIG. 4.—CONDENSER COMPLETED.

As described, the condenser would be suitable for potentials of 10,000 volts or less. For higher potentials the plates between the conductors may be made thicker. This will reduce the capacity of the condenser both by increasing the thickness of the dielectric, and reducing the number of plates that can be placed inside a jar of given dimensions.

The ball and knob arrangement is very simple. Some $\frac{1}{16}$ in. brass rod is bent into a ⅛ in. eyelet at one end, while on the other is cast a round leaden bullet. These rods are bolted each to its system of plates on the rod holding the plates together. They will serve to separate the tin plate at the points where they are bolted in, instead of washers, and will bind a sufficient amount to hold them in any position that they may be placed; as they are placed opposite each other the discharge gap may be varied at pleasure.

For use with the higher potentials, the jar had better be of hard rubber, for it is liable to be punctured, and if this happens the jar will crack and release the oil to the great discomfiture of the experimenter.

One of the chief practical features of this condenser is the facility with which it can be repaired. Should a plate become punctured for any reason, it may be at once withdrawn and renewed without disturbing the condenser otherwise in any way. The expense of repairing such a condenser is practically nothing. If redesigned for manufacture in large quantities, its cost could undoubtedly be brought below the dollar limit.

◆

INTERIOR WIRING.

SWITCH CONTROL FOR ELECTRIC SIGNS.

An electric sign is merely a series of lamps forming letters for the word or legend displayed. The primary object of the sign is to attract attention thereto, and in this respect its utility can be greatly enhanced by appropriate switch control. In the first days of electric signs it was quickly found that simply turning on and turning off the sign current called more attention to it from the streets, and this, as may be noted even now on upper Broadway, is still extensively done.

Such progressive switching requires the constant attention of a man or the employment of an automatic device driven by a motor, and the latter is always preferable. Inasmuch as the remainder of this article will deal with progressive switching, although more elaborate methods than the one already mentioned will be discussed, a description of an effective progressive switch adapted to be driven by a small fan motor will not be out of place.

This switch consists of a shaft of machinery steel turned as shown in Fig. 1, and suitably threaded to receive standard ½ in. check nuts. The portion of the shaft between the threads is to be insulated to the diameter of 1 in. This may be done by slipping over it a fibre tube $\frac{1}{16}$ in. thick, or by winding paper over the shaft tightly and securing it with glue as it is wound on.

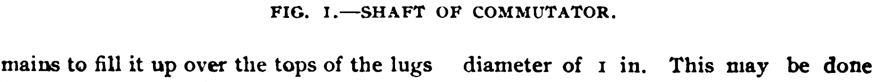


FIG. 1.—SHAFT OF COMMUTATOR.

Thirteen rings should now be cut from ¼ in. sheet hard rubber. They should have an internal diameter of 1 in. and an external diameter of 2 ins. Prepare a pattern to produce the casting shown in Fig. 3, and have twelve of them cast in brass. Slip them on the shaft, separating them with the rubber rings from each other and from the nuts. Set up the nuts and put the shaft in a lathe and turn down the curved surface until the scale and roughness are removed. The angular position of the castings may be varied to produce effects that will subsequently be described. The shaft turns in ¾ in. iron boxes with self-aligning swivels, such as are shown in Fig. 2. These bearings and pedestals may be bought ready made from a dealer in models. The shaft with its load of insulated castings is mounted in these bearings, and a suitable pulley, preferably a grooved one, is fastened to the protruding end of the shaft so that the latter may be rotated.

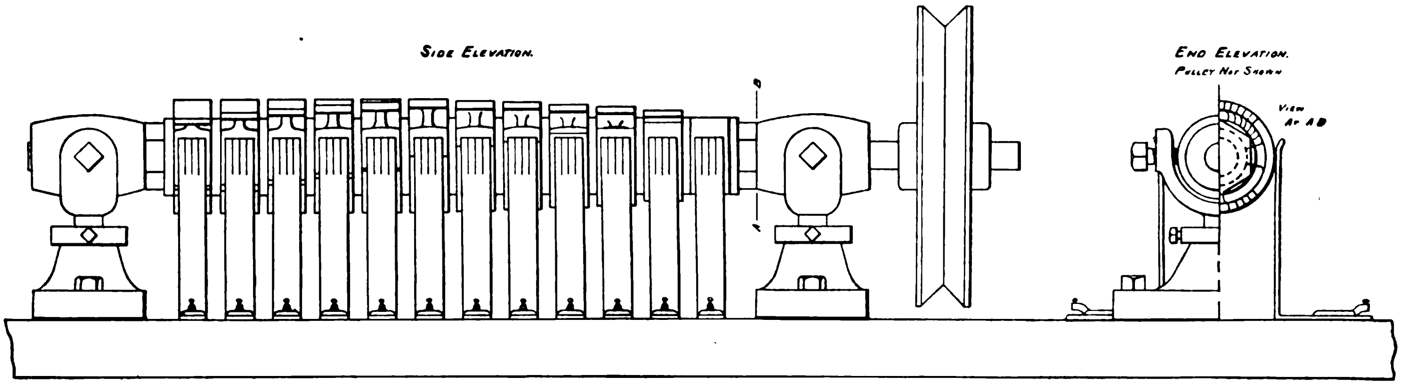
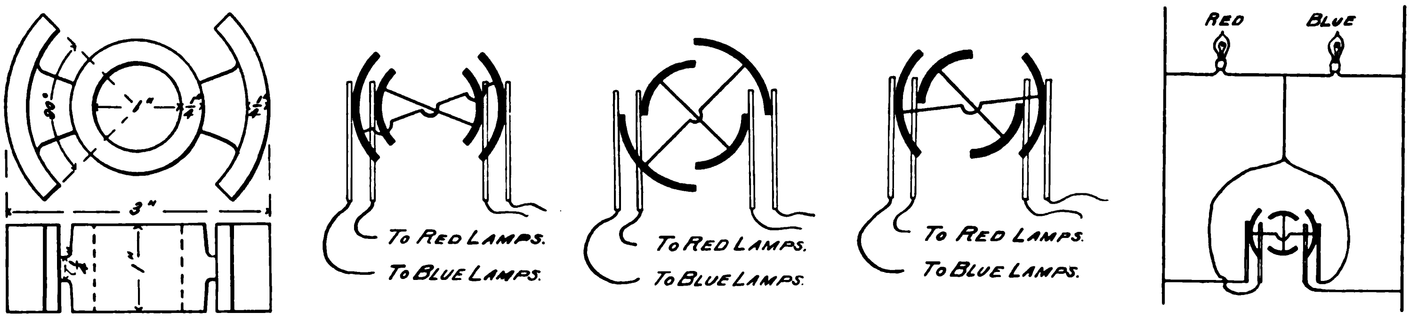


FIG. 2.—COMMUTATOR COMPLETE.

Each casting revolves between two brushes which press against its periphery, as shown. The ends of these brushes are provided with little terminals into which wires may be fastened. The twelve castings, each with its pair of brushes bearing thereon, may be considered as parts of twelve circuits, and wherever a casting and brush is interposed, the current will be intermittent through equal periods of time, whatever the speed. The current will be on half the time and off half the time, and the lengths of the intervals of outages and illumination may be varied by simply varying the speed, but their equality will not be changed thereby. A convenient speed for the spindle is three turns per minute. This will give alternate periods of five seconds each on a simple circuit through one of the switches.



FIGS. 3, 4, 5, 6 AND 7.—COMMUTATOR CASTING, AND VARIOUS SWITCH COMBINATIONS.

It is obvious that by varying the angular position of the switches relatively to each other that the events of one circuit may be varied with respect to the others, and thus many pleasing combinations can be produced. Suppose, for example, that we have a large sign of alternate red and blue lamps, and in sufficient number that either the red or the blue lamps would sufficiently trace a letter to make it appear well. Let each color have a separate circuit. Let two castings on the shaft of the progressive switch be inserted in the two circuits of the sign.

Now if the castings are lined up so that they occupy the same angular position on the shaft, indicated in diagram in Fig. 4. the sign will light up with all its lamps for a period, and remain dark for an equal period. If the castings are set so that one quarters the other, as diagramatically shown in Fig. 5, then the sign will light with red and blue lights alternately, the blue lighting as the red go out, and *vice versa*. If the castings occupy any intermediate position (see Fig. 6) between these two, there will be two more effects introduced, making four in all. First, the sign will burn red, then red and blue, then blue, and then follows an outage equal in length to the length of time the lamps were all lighted. This cycle is then repeated. By varying the angular position the events may be allotted such periods of time as may produce the most pleasing effect for the particular sign in use.

If the circuits of the progressive switch are connected *two in multiple* and a single current passed through them, the effect of varying the relative angular position of the two castings on the shaft will vary the time of outage from zero to one-half the time of a complete cycle. By connecting the castings *two in series*, variation of the relative angular position will vary the period of outage from one-half a cycle to a complete cycle or, in other words, darkness. Briefly, by the devices just indicated the period of illumination may be anything from a mere flash of the lamps once per revolution to continuous light. This extends the scope of the switch very materially.

We will thus have six circuits which can supply current for practically any fraction of the time of one-half a revolution desired, and remain dead for the remainder of that period. Moreover, we can adjust the relative order in which these events occur, by simply varying the relative angular position of the *pairs of castings* representing the circuits. A number of instances illustrating the general applicability of this switch will now be given. Suppose that a theatre wished to display the name "Hamlet." By means of this progressive switch properly set, the word could be spelled in order H-A-M-L-E-T, followed by a general extinction and then a repetition of the display. Any sign could thus be lighted up in progressive order and then extinguished. This is the popular way of manipulating electric signs and is usually done by hand.

As mentioned in the paragraphs on theater wiring, the brilliancy of lamps may be varied by connecting them two in series across the mains. On the sign utilizing this principle, a pretty effect may be obtained by so arranging a pair of castings on the shaft as to short circuit a set of the lamps thus connected in series. If there were red and blue lamps in series forming the letters of the sign, the blue lamps would suddenly disappear and the red ones would come up to full brilliancy, or *vice versa* as might be desired. By connecting two castings in multiple at the wire connecting the lamps and connecting the free ends to the two sides of the mains, as shown in Fig. 7, three effects will be produced—first, a red sign, then a red and blue sign at half brilliancy, and then a blue sign. The middle event would occur for only an instant. This combination gives no outages, but care must be taken that the two castings are exactly on the quarter, for if circuit is made through them simultaneously it will short-circuit the mains. It may be necessary to use castings having a less arc than 90 degs. to accomplish this.

If it were desired to attract attention to any great extent, a comic feature could be introduced by tracing an animal such as a dog, in incandescent lamps. If he be given a plurality of tails and eight legs suitably arranged, the simple device of switching the current from one set of members to the other will cause him to appear to run and wag his tail quite naturally, while to make him wink is a still simpler matter. For such service the progressive switch already described will be found excellent. A comic artist with a fertile brain would find no difficulty in designing striking subjects, and in the manner just indicated almost anything can be accomplished. Anything that can be produced on the double magic lantern slides can be repeated by this method on the electric sign.

The circuits of an electric sign usually have single pole control, although a large double pole gang switch should be provided for purposes of general extinction in order to comply with the insurance rules. In composite signs so wired, the same pole should be given all the lamps except in special cases, for the combinations will work out more conveniently. Care should be taken that no lamps are common to both of two interchanging circuits, for the result would be that neither would interchange, but both would burn all the time. This is a mistake that has been frequently made. In fact whole boards have been failures because they have been constructed in ignorance of this principle.

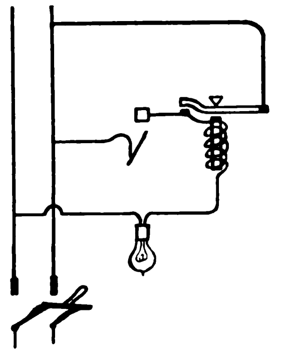


FIG. 8.—ELECTRIC SIGN MECHANISM.

A convenient system of electric signs is in use whereby the letters of the sign may be changed with great facility. The letters are traced in lamps on pieces of board having brass connecting clips at the top and bottom. A long rack is prepared to receive the boards and is suitably grooved to retain them. The spring contacts on the ends of the letter boards make contact with two brass rails connected to the mains. With a set of letters like a font of type any combination of letters can be constructed. These letters are usually traced in minature lamps.

This article would hardly be complete without a description of the Manhattan Beach sign, for although the sign is most expensive and its foundation principle is broadly covered by patents, it is interesting as being the most flexible electric sign in existence. Its principle is as follows: A lamp is in series with a small magnet and also with a pair of contacts that are closed by the armature thereof, as shown in Fig. 8. Should the lamp get current even for a moment the armature would be attracted and maintain the circuit even after the original source of current is taken away. A large number of lamps are packed as closely as possible on a board. They are permanently connected to one side of the circuit, while the other side is connected to each lamp, by means of the mechanism of the magnet and armature just described. A board covered with little plates is connected to the lamp board by the controlling wires so that every plate to which a wire is connected occupies on its board the same relative position that the corresponding lamp occupies on the sign. Each of these plates is connected to its lamp beyond the break in the circuit in the magnet armature. Thus if a stylus of metal connected with the other side of the mains be touched to any of these plates the circuit will be closed, and *held closed* by the magnet even after the stylus has been removed. Thus any lamp or line of lamps may be lit and any letters traced. A gang switch restores the sign for a new sentence.

FAULTS IN DYNAMOS.

With respect to faults in the connections of the armature, it is well to note that in some cases the test of the bottle of glycerine and iron filings is not accurate for all windings. There are a few drum windings that are what is called "chord wound." This winding has the disadvantage of throwing conductors with inverse E. M. Fs. into the the field where they do not belong, but has an advantage in greatly reduced armature reaction. In order therefore to intelligently apply the test the operator must know his armature and whether or no it partakes of the chord winding. Such windings are not very common.

There is a class of machine that is so totally different in the character of its armature winding that it requires special treatment. These are the open coil machines used for arc service. There are only two of these machines that are largely used, the Brush and the Thomson-Houston, and each will be accorded a separate discussion.

The Thomson-Houston armature connections are shown in diagram in Fig. 1. There are two well known methods of winding this armature. The old fashioned way was a drum method, but the three coils overlapped so badly that it was very difficult to repair. For this reason a Gramme ring armature was adopted on account of the ease of repairing a burned out coil. Electrically the two armatures are identical, the winding being divided into three parts connected together at one end and delivering their free ends to the commutator. (See Fig. 1.) The station manager or dynamo attendant is frequently called upon to connect these coils up correctly, and though he succeeds eventually he often makes needlessly hard work of it.

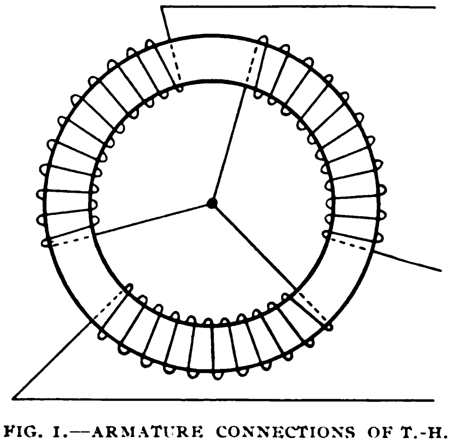


FIG. 1.—ARMATURE CONNECTIONS OF T.-H. ARC DYNAMO.

There are three wires and three commutator segments, and their proper connection is very easy to accomplish. Draw a circle and endeavor if you can to place the figures 1, 2 and 3 about its circumference, so that they will not come in order. This will be found to be impossible. Only two combinations can be had however the figures are twisted, one running around the circle left handedly, while the other traverses the circle in a right handed direction. Thus there is only one way of connecting the commutator up wrongly.

First set the commutator at the proper position on the shaft so that the brush leaves the commutator segment in front of an air blast nozzle. Then connect the wires into the segments as they happen to come, and try the machine. If incorrectly connected it will refuse to generate though it may give evidence of electrical energy at the commutator by sparking. Try this combination at three points, advancing the commutation a third of a turn at each trial. Failure to generate still being the case, stop the machine and exchange *two of the wires* of the commutator with their respective segments. It will now be correctly connected and it remains only to find the correct lead by the three trials.

A little adjustment of the lead of the commutator on the shaft after the correct position is found may be necessary in order to prevent flashing. This adjustment should be made so that the spark at the brushes will be normally about $\frac{3}{32}$ in. long. It is an even chance that the wires will be connected the first time in correct order, and if the first trial fails the second is sure of success. A common mistake is to take all three wires and rearrange them, a process that often produces the same combination that was tried before. A moment's thought will show the uselessness of such procedure. The lead of the commutator being correct, it is obvious that no mistake can be made by connecting one wire to one segment provided the other two are properly connected relatively thereto. There are only two ways that the remaining wires can go. One is correct and one is not. Try each at the three possible positions and the chances are that before the six combinations of lead and connections are exhausted the correct one will be found.

The Brush arc dynamo, unfortunately, is not so easy to connect, and there are liable to be more mistakes. On a four-pole machine, the difficulty is often quite complicated, and in fact the connections of the first machine of this type bothered its own designers. For simplicity's sake the connections of the bipolar machines will be discussed first. In a bipolar Brush dynamo the opposite bobbins are connected in series. This, of course, engages two of the four ends of the two bobbins and the other two ends are connected to a two-part commutator. Thus there are as many two-part commutators as there are pairs of bobbins. If there are eight bobbins there will be four commutators, if twelve, six, and so on. It may be added that six is the largest number of commutators yet used on any Brush open coil arc dynamo.

These commutators are grouped together in pairs, one set of brushes bearing on two commutators, thus connecting them in multiple. The gap space in these commutators is very wide and is bridged with a block of lignum vitae. The gaps are so set that they are practically at right angles to the radial line passing through the coils to which they are connected. As the coils are placed at equal angular distances about the ring, the commutators are also spaced at equal angular intervals about the shaft. They are always grouped so that any two commutators coming to a single brush are at right angles to each other. Fig. 2 will give a good idea of the connections of the armature and commutators. With this knowledge the attendant should have no trouble in connecting the armature up correctly or discovering an error in the connections. It remains, therefore, to describe a few of the improper connections that are likely to occur and the readiest method of detecting and remedying them.

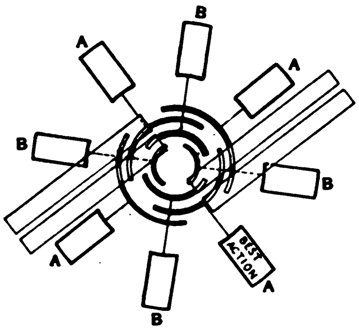


FIG. 2.—ARMATURE CONNECTIONS OF BIPOLAR BRUSH ARC DYNAMO.

It may be added that improper connections are accompanied by furious and incurable flashing, refusal to generate, or refusal to give the maximum rated voltage. One of the first errors in connection that is likely to be encountered, is the connection of two bobbins in opposition. This will result in the machine giving a less voltage than the rated maximum. To locate the trouble select the position of best action, shown in Fig. 2, and hold opposite the bobbin in that position a small pocket compass. Pass a current through the armature, being careful that it does not pass through the field magnets also. It is better to short circuit the fields by the switch provided for that purpose. When the current is established in the bobbin under test, the needle of the compass will deflect. Slowly rotate the armature and test each bobbin successively as it reaches this position of best action. The deflection due to all of them should be the same, and if any produce an opposite deflection their terminals should be reversed. This method might be employed for similar errors with respect to the Thomson-Houston arc machines.

Another cause of the machine's failing to generate its full voltage is the short circuiting of a bobbin. Its self induction is so great that the current generated in it will not burn it out with anything near the promptness that the low resistance coil on a constant potential machine would under similar conditions. The faulty coil may be detected in the same way that the other case of reversed connections is discovered. Without moving the compass, try each bobbin successively. Note the *magnitude* of the deflections. It will be pretty safe to assume that if a bobbin produces a notably less deflection than any of its fellows, the current being constant, it is probably short circuited in all or a part of its turns.

Sometimes the wrong bobbins are connected to one of the commutators. To test this, ring from the bobbin on the armature to the commutator with a magneto. The wire of the magneto may be wound upon a sharp knife, and pressing its edges against the insulated wire of the bobbin will make sufficient contact with the wire for the purposes of this test. Be sure that the brushes are removed, for they connect the bobbins together in a very confusing and variable manner. Bear in mind that if one bobbin rings to a certain commutator, the next bobbin on the armature should ring to the commutator in next angular order on the shaft, and that as the test continues, the commutators advance in lead with the bobbins. *Two adjacent bobbins should never ring to two adjacent commutators.* Opposite bobbins should ring to the same commutator.

The four pole machine, which is now more generally used than the bipolar type, is not quite so simple. Each commutator has four plates, and the two free ends of four bobbins equally spaced about the armature and in series are connected to two adjacent plates of this commutator. These plates are connected each with the plate directly opposite by a small piece of wire. This is called cross-connection. The four bobbins of a set are 90 degs. apart. As there are six commutators, there are twenty-four bobbins; the bobbins advance around the shaft by twenty-fourths, and so do the commutators to which they are connected. Commutators at 45 degs. with each other are grouped together under the same brush. They come in pairs. For simplicity Fig. 3 shows but eight bobbins connected to one pair of commutators. The brushes of this machine are set on the quarter. Errors in connecting up the coils out of conjunction are discovered and remedied in precisely the same way as on bipolar machines. Errors in connecting the wrong coils to the wrong segments can be found by testing with a magneto and carefully noting how the coils *should* be connected. The same remarks as were made with respect to bipolar machines apply, with the exception that bobbins in electrical circuit are on the quarter as well as on the half, and that every set of bobbins comprises four instead of two.

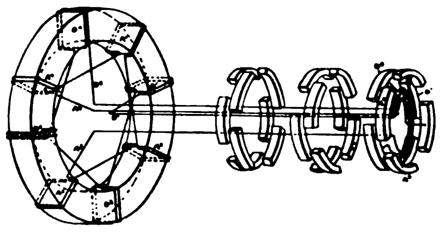
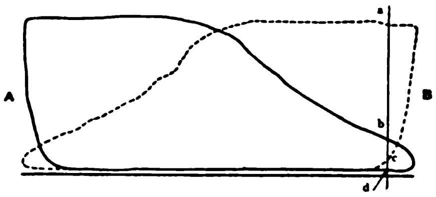


FIG. 3.—ARMATURE CONNECTIONS OF 4-POLE BRUSH ARC DYNAMO.

THE STEAM ENGINE INDICATOR CARD.

A correspondent asks, why, in measuring pressures on indicator cards, the length of line cut off between the steam and exhaust the same card is used, instead of, as in Fig. 1, the length between the steam line of *A* and the exhaust line of *B*. He adds that, since the piston when card *A* is being drawn, has behind it the back pressure of card *B*, the real unbalanced pressure is represented by the length of line cut off between the steam line of one card and the exhaust line of the other.

The point is a good one to bring up. There may be a very considerable difference in the lengths of the ordinates measured according to the second method, but the *average value of the lengths is the same by either method.*



If we wished to know the horse power separately of either side of the piston, then the second method would be absolutely necessary, but as only the *average* horse power of both sides of the piston is required, this is obtained as correctly by one method as by the other. The reason of this will be made plain by reference to Fig. 1, and by adding together the lengths of lines according to both methods. Thus,

	First method.	Second method.
Card *A*	$bc + cd$	bc
Card *B*	$ab + bc$	$ab + bc + cd$
Average	$\frac{ab + 2bc + cd}{2}$	$\frac{ab + 2bc + cd}{2}$

From the above it will be seen that while the value of the pressure as given by the first method applied to card *A*, is too great by the length of *e d*, on the other hand it is too small by the same amount *e d*, for card *B;* one thus corrects the other and the average remains the same. At any other point of the stroke the same reasoning applies. In some engine calculations, however, as in determining crank torque, the second method must be used.

As shown in the August number, the ideal line of expansion of an indicator card may vary widely in shape and location from the actual expansion line. Yet almost invariably writers on indicator cards give methods for determining the point of cut-off, the clearance and the consumption of steam per I. HP, which, in fact, are based upon the assumption that the ideal and actual expansion lines coincide. This assumption is never true, and even in a perfect engine would not be true if the ideal hyperbolic expansion line were used, as steam in expanding follows a curve different from the hyperbolic curve.

Equally fallacious is the teaching of such writers that by drawing the ideal curve (which they usually wrongly designate as the "theoretical" curve), leakage of steam may be detected. The card of Fig. 2 was taken from a new engine by the makers in their shop, the engine, of course, having been thoroughly tested for leakage. According to the method for testing leakage just referred to, the piston of this engine was in a woful condition, for near the end of the stroke the card shows the cylinder to contain only about two-thirds of the steam that it should if their method is correct. If, however, there had actually been a valve leakage considerable enough to bring up the actual ideal expansion line to the ideal line, the engine would have been pronounced not only in good condition, but praised for its excellent steam performance. Leaving aside exceptionally good Corliss engines, it may be accepted that the ideal expansion line cannot be depended upon for determining leakage with any degree whatever of reliability.

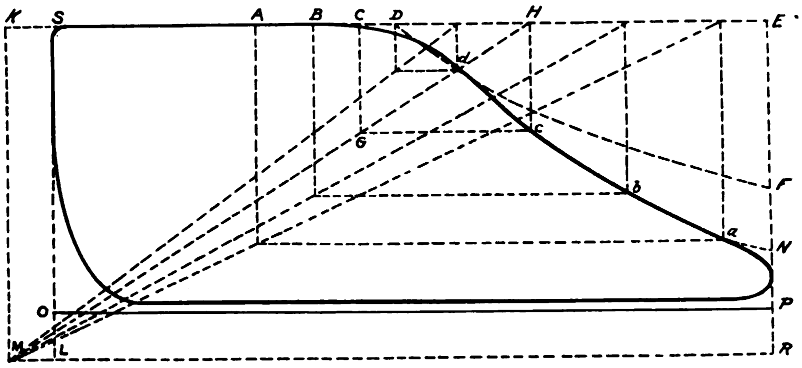


FIG. 2.—METHOD OF DETERMINING POINT OF CUT-OFF.

A method given by some writers for determining clearance is based upon a similar construction to that shown in Fig. 2 (explained in detail in the August issue), but applied to the compression line. We have seen what absurd results that construction gives in the determination of the point of cut-off, which comes at A, B, C or D, according to the point which has been chosen on the expansion line. As the same principles apply in determining the clearance, similar divergences are met with, so that it would be mere waste of space to describe the method.

It may be asked, What method, then, is there for determining piston or valve leakage from the indicator card? This may be done with some degree of reliability by making from time to time the calculation, explained in detail in the July number, for determining the indicated consumption of steam per hourly horse-power, and then comparing results with previous calculations. For this purpose about the same point of the stroke of the card should be used each time, and the comparisons should be made between cards of nearly equal horse-power.

In order to give a direct illustration of this method, an example will here be calculated. The reader is referred to the July number for a full explanation of the method and for the derivation of the formula.

The indicated pounds of water per horse-power hour may be obtained from the formula·

$$\frac{35.47\,(p + 14.7)\,(f + c)}{P}$$

where

p = pressure above atmospheric line at chosen point of stroke of card.

P = mean pressure of card.

f = ratio to whole stroke, of stroke to point of pressure p.

c = clearance.

The card in Fig. 3 is from a 22 in. by 48 in. Corliss engine making sixty revolutions per minute, the scale of the card being forty pounds, and the clearance four per cent. (.04). Adding up the ordinates on a slip of paper, we find their total length to be eleven inches, which corresponds to a mean pressure (P) of 23.28 lbs. Let B be the point chosen for calculating the indicated steam consumption. Measuring, we find $D B$ to be one-quarter inch above the atmospheric line, and therefore corresponding to ten pounds pressure (p). The length from A to C measures $3\frac{15}{16}$ ins., and from A to B $2\frac{5}{8}$ ins.; the fraction of stroke (f) is then

$$\frac{A\,B}{A\,C} = .603$$

The clearance is given at .04.

Now substituting in the above formula, we have

$$\frac{35.47\,(10 + 14.7)\,(.603 + .04)}{23.28} =$$

$$\frac{35.47 \times 24.7 \times .643}{23.28} = 24.2$$

indicated pounds of steam per hourly horse-power.

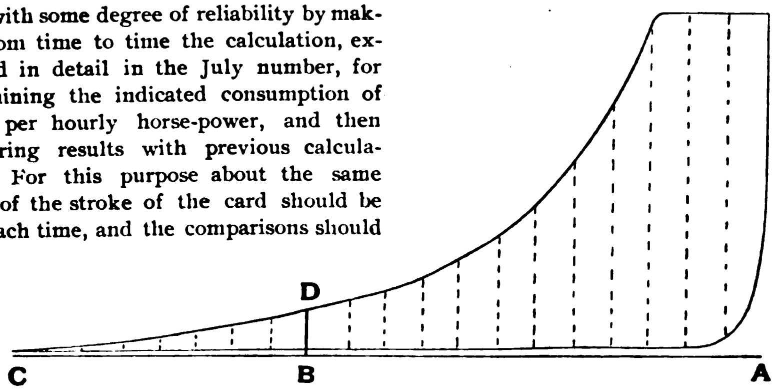


FIG. 3.—METHOD OF DETERMINING INDICATED STEAM CONSUMPTION.

By laying down on the card of Fig. 3 the ideal expansion line according to the method given in the August number, it will be found to very nearly coincide with the actual expansion line, and therefore the amount of steam indicated in this case is probably little less than the actual consumption. This coincidence, however, rarely occurs. As, however, the divergence of the ideal and actual expansion lines is a measure of the efficiency of an engine (provided there are no leaks), it is instructive to lay down the ideal line for that reason.

REPAIR OF ELECTRIC RAILWAY APPARATUS.

BY W. E. SHEPARD.

THE GENERAL ELECTRIC MOTOR.

The G. E. 800 motor is one which has, during the past two years, come into very general use throughout the country. In many respects similar to its immediate predecessor, the W. P., it is, however, more completely encased and protected more thoroughly from dust and moisture. The bearings are also of much better design.

The W. P. is arranged with but a single field-coil bolted to the upper half of the motor frame, with a corresponding, "consequent," polar projection at the bottom. The G. E. has two field-coils, one bolted to the upper and one to the lower half of the frame, each producing the same polarity; the opposite poles are formed, one on either side of the motor, the frame or casing of the motor, when thrown back, dividing along the center lines of these consequent pole faces.

Three types of G. E., motor have been designed for the more usual street railway work, the G. E. 800, 1000, and 1200. The former is the first put out by the General Electric Company, the latter two being modifications, more or less, from the original design.

The G. E. 800 motor, shown in Fig. 1, has a number of parts which it will be of interest to consider. Its repairs are not confined to any particular member, but are rather general. The original motor was designed with a ring armature. Not many of these, however, were put out, the ring being superseded very shortly by the drum form.

Occasionally a shaft may become loosened—the body of the armature, moving slightly back and forth on the shaft. When this is the case, there is no satisfactory remedy other than the replacing of the shaft by a new one. Care should be taken, however, that the new one is larger than the standard diameter (2¼ ins.) by an amount depending upon the degree of looseness of the shaft. The new shaft may be driven home by means of a heavy sledge and flatter or, better, by a hydraulic ram. In the latter case a pressure not to exceed ten nor less than five tons will insure a secure fit.

The shafts of the G. E. 800 motor are all removable by first drawing off the thrust-ring at the end of the shaft near the commutator, and then sledging or pressing on the end of the shaft next the commutator. This is a very considerable advantage over some other types of motors, and frequently comes into use in cases of sprung or bent shafts, allowing, as it does, of easy repair of shaft and return to its original place without any harm or damage to the windings of the armature, which in no way have to be disturbed.

The bearings fitted with most of these motors are of the cast-iron, babbitt-lined style. The pinion end is 2½ ins. × 6 ins., the commutator end 2½ ins. × 4½ ins., each lubricated by grease fed to the bearings from pockets, by gravity only.

These bearings are the most vital part of the motor and will bear the most constant watchfulness. A superior grade of mineral grease is best, and the pockets should be inspected and filled at least every second or third day, and the first of each month they should be thoroughly cleaned. That is, all the old grease should be removed and put into the gear casings, the pockets washed with two or three spoonfuls of kerosene and filled with fresh grease, the slots through which the grease feeds being carefully picked free of any grit or hardened substance which may have lodged in them.

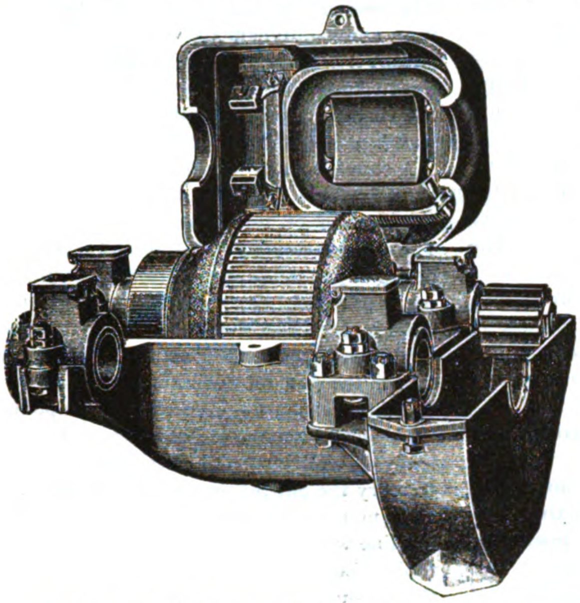


FIG. 1.—G. E. 800 ELECTRIC RAILWAY MOTOR.

When these precautions are taken and carefully carried out month after month, if the babbitt is of thoroughly good quality, and the bearings are properly fitted to the shaft they are to run with, every babbitted bearing will wear with entire safety for a period of three months' constant use, or a distance of between ten and twelve thousand miles, irrespective of time. When a bearing has covered this distance, it can well afford to be taken out and replaced by a new one. Some prefer to cast bearings to the size of shaft on which they are to run; the better way is, however, to cast them considerably smaller in diameter and then turn them up in a lathe to the exact size of the shaft, since a truer and more reliable result will be obtained in this way.

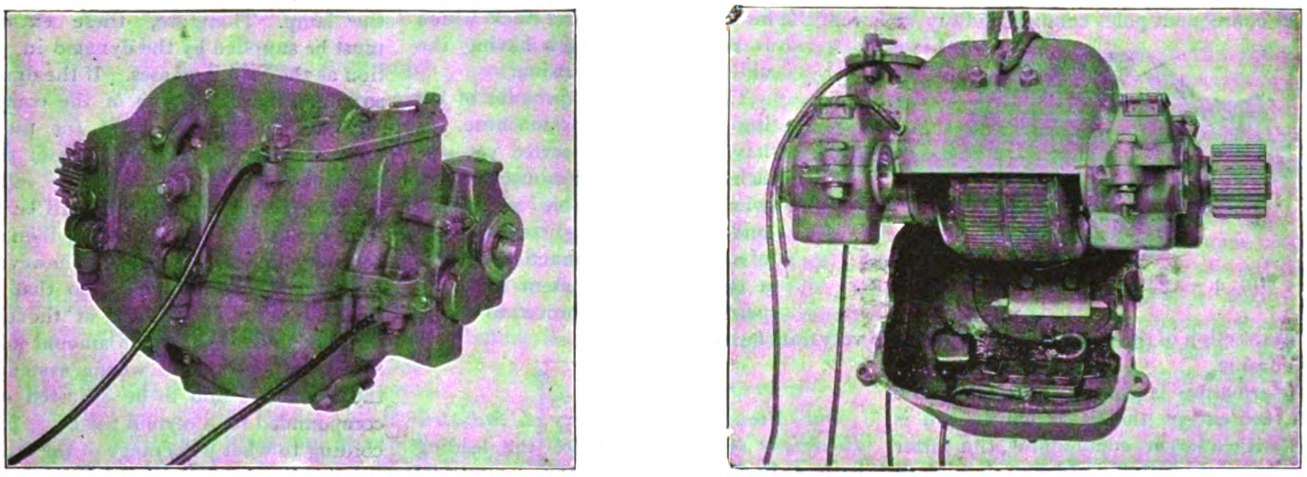


FIG. 2—G E. 1000 ELECTRIC RAILWAY MOTOR.

Armatures of several different windings are used in these motors. The earlier was composed of 105 coils, each coil consisting of three turns of No. 10 wire. Later the grooves in the armature core were deepened and coils of No. 10 wire, each four turns deep, were used. The more recent are made up of No. 9 wire of four turns to the coil.

All of the 105 coils which go to make up a complete armature are exactly alike, being wound on a former and shaped, after the Eickemeyer plan, in such a way that they interlock and overlap each other, one-half of each coil appearing in the outer layer and outer head, the other half being beneath in the bottom of the slot, and forming the inner head.

The earlier armatures were connected to the commutator through short lengths of flexible cable. The advantage of such connection is that in event of a commutator becoming loose on the shaft, the vibrating motion resulting will not break the leads and so result in an open or broken circuit in the armature. The later armatures do not use this flexible lead, the wires from each coil being carried direct to the commutator, thus doing away with an exceedingly awkward splice and rendering the work of connecting much more easy and simple. As a well fitted commutator will very rarely become loosened on its shaft, this method should introduce no objectionable results.

In the G E. 800 motor the field-coils work under unusually severe conditions. There being but two of them, in the event of one becoming damaged by a ground or short circuit, the magnetic field of the motor becomes greatly weakened and unsymmetrical and, unless the injured motor is at once cut out of circuit, the remaining coil and the armature are almost certain of injury. The location of the lower field-coil increases the liability to this trouble, as it is placed flat down on the bottom of the motor where oil and moisture collect in spite of any precautions which may be taken. The later motors sent out from the factory have the lower coil incased in a wrapping of sheet lead, which is carefully soldered along the seams, forming a moisture-proof sheathing for the coil. This has been found to very greatly aid in protecting the coil, and besides protects the armature from one source of exceedingly severe strains.

The later motors are also built with the armature shaft tapered for fitting to the pinion. This will be found a decided advantage over the older method so long employed, of shrinking the pinion on to a cylindrical shaft. Where the cylindrical shaft is used, considerable difficulty is sometimes experienced in removing a pinion, a very powerful pinion puller being required to start it; besides, the repeated drawing off of a tight fitting pinion rapidly lessens the diameter of the shaft, so that, finally, a standard pinion will no longer remain secure, and as a result the older shafts must be thrown away or else a smaller and odd bore adapted for the pinion.

This latter difficulty may be greatly lessened, although it cannot be wholly overcome, by making a heavy cut along the pinion between two of the teeth just over the key-way, by means of a blacksmith's side chisel and a heavy sledge. Such a cut will be found to spread the metal of the pinion and it may then be drawn off much more readily with correspondingly less friction and wear on the shaft. Where the later type of taper pinion and sleeve is used, it is best to warm the pinion slightly, not quite "sizzling hot;" then putting in place and drawing up snug by means of the heavy nut on the end of the shaft.

One matter which will be found to give a good deal of trouble is the loosening up of various bolts of the motor. As sent out, most of these bolts have been secured by a single nut and a cap nut-lock with split pin. The latter does not prove reliable and should be taken off and replaced by a good split-washer, which will insure a much more secure fastening.

These motors are so designed that the armatures must, in all cases, be removed from above. That is, the top and bottom halves of the motor are hinged together, and in order to remove the armature, the top half is thrown back and the armature lifted up into the car body and then carried out through the door of the car. A wooden horse or tripod is usually employed to raise the armature; a plank is then placed under it and the armature lowered into a cradle in which it is rolled out to the door, A much more convenient method will be found that shown in Fig. 3. A long heavy boom is supported from a stiff beam firmly secured at the end of one of the tracks, a light block and tackle being hooked to the extreme end of the boom. The car is run over the pit until the block and tackle is directly over the armature, the boom projecting through the door; the armature is then raised and the car run back by its own power, leaving the armature suspended ready to lower down on a wagon or be hooked to an overhead traveling crane.

With this arrangement one man and a boy can easily take out both armatures from a car, leave them on the floor to be cleaned and dressed up, and replace them with two new armatures with new bearings in an hour's time.

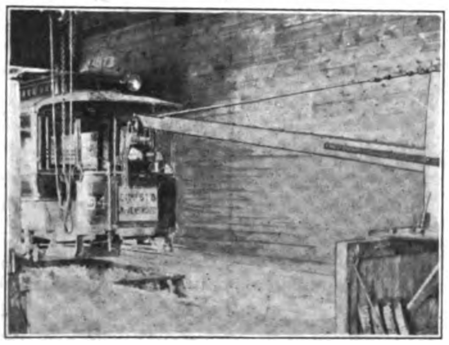


FIG. 4.—METHOD OF REMOVING ARMATURE.

The G. E. 1200 is designed very much after the plans of the G. E. 800. It is, of course, very much heavier than the latter, its weight being 2700 lbs. without gears or gear covers, while the G. E. 800 is 1550 lbs. It has the same arrangement of two field coils, one placed at the top, the other at the bottom of the interior of the motor, with similar consequent poles coming midway at the intersection of the top and bottom halves of the frame.

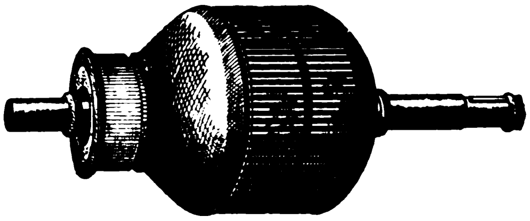


FIG. 4.—ARMATURE OF G. E. 800 MOTOR..

The armature is similar in detail to the G. E. 800 except that it is longer and is fitted with a larger commutator, the latter being arranged with two brushes in each of the two brush holders in place of one as in the other motor. The bearings are babbitted and, like the G. E. 800, the two halves of the frame are hinged and the armature arranged to be taken out from above. The motor is, of course, much more powerful than the G. E. 800, but is not of so high a speed.

The latest motor designed by the General Electric Company is the G. E. 1000, which is intermediate to the preceding. The total weight of this motor is 1950 lbs.

It is designed on somewhat different lines from the others, having four "salient" poles instead of two salient and two consequent poles, and in this way a rather better balanced field is assured. The four field projections with their four corresponding coils are placed, not flat down on the bottom of the motor, but on an angle of 45 degs., one on either side of the center of the top and bottom halves of the frame. In this position, whatever of moisture may find its way into the interior will run down away from the field-coils to the lowest point, which comes between the field-coils, thus rendering the coils much less exposed to the moisture and possible damage.

Also, in event of a coil becoming damaged, there is less liability of injury to the armature and remaining three coils, since the field is divided into smaller units. The heating of the coils also is divided over a greater surface than in the two-coil motors.

The bearings are quite similar to those of the G. E. 800, are babbitted and so arranged as to allow of the use of either grease or of oil as a lubricant.

The brush-holder is much improved over the old form. They are hung so that the brushes are held radially to the commutator and do not have to be beveled as in the G. E. 800; the yoke receives a special insulating treatment and is finished in enamel. This will prevent the adhering of fine particles of carbon and copper dust to the holder and a consequent breaking down of its insulation.

The armature of this motor is constructed quite similarly to the G. E. 800, being what is known as "slot," wound. It has, however, but ninety-three coils of four turns each in place of 105 as in the other; one terminal of each coil is brought out at the center of the coil instead of at the corner, so that the removal of an injured coil is considerably facilitated.

A special "yoke," arrangement is made for the support of the motor whereby a balanced suspension is secured, tending to prevent the heavy pound upon the track which is usual with motors having the older style of suspension.

This motor gives promise of being a very superior machine. It has not been in service yet sufficiently long to demonstrate just what it will be able to endure under the exceedingly severe usage of modern traction practice, but it is a decided improvement in many points and will prove to be a very satisfactory motor.

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X-Fakes.

Our French contemporary *L'Industrie Electrique* states that one of the leading hatters in Paris is selling an "electrical leather," an advertisement of which reads as follows: "To preserve the sight, to re-establish it in a few weeks if weakened, to avoid headaches and dizziness by *means of your hat*—this can be done by applying to the head band of new or old hats, our X-elements, the positive pole of which has a gold base." A new medicine is at present being advertised under the name of X-ode; the advertisement opens with a sentence referring to the wonders of the X-ray, and then gives a list of diseases that will be cured by the new remedy, which is described as electrical in its origin—the connection, however, between the X-ray and X-ode not being stated.

HOW TO COMPOUND A SHUNT DYNAMO.

There often arise cases where it is desirable to add compounding coils to a shunt dynamo. It may be that new compound machines are added to the plant, and it is therefore desirable to run in multiple therewith the shunt dynamos already installed. Again, it may be that in an isolated plant, the engineer has become tired of adjusting his rheostat to the varying loads and is in search of something better.

A shunt dynamo can be compounded with great facility It is not necessary to know the number of turns on the shunt spools. The magnetic circuit is already properly designed for the purpose, for the compounding is to accomplish a regulation previously done by the hand rheostat. It is not necessary even to move the machine from its location in the dynamo room.

The necessary appliances for compounding a shunt dynamo are as follows: A sufficiency of well insulated wire heavy enough to carry the entire current load, some adhesive tape, some stout hempen cord (half marline will answer), and a kit of soldering tools. Besides this, only a knowledge of the amount of over-compounding is necessary.

For the benefit of those not conversant with compounding, it may be stated that its theory is briefly as follows: As the current in the network of supply wires increases, more and more voltage is required to force this increased current through these wires, and also through the wire on the dynamo armature. If no means of regulation are provided, this voltage will be taken from that of the lamp terminals. Now it is very desirable, for a number of reasons, that the voltage of the lamp terminals be maintained constant, and equal to the rated voltage of the lamp. Therefore, these extra volts must be supplied by the dynamo in proportion as the load increases. If the dynamo is so wound that the action of the compounding coils just compensates for the extra volts necessary to push the current through the armature of the machine, the voltage at *the terminals of the machine* will be a constant quantity. The dynamo is then said to be compounded simply. If, however, the compound coils are wound so that as the load comes on the voltage at the dynamo terminals *rises* a sufficient amount to make up for the loss in the wiring system, then the dynamo is said to be adjusted or over-compounded for a certain per cent. loss, according to what percentage of the lamp voltage this line loss may be.

Let us assume a case very likely to occur—that of an enterprising engineer of a smal isolated plant, who wishes to compound his dynamos. He has been recently put in charge of the plant, and therefore knows nothing of the loss in the line, or in the armature of the machine. These, and other points, are the things he must discover. To handicap our engineer still further, he has but one voltmeter and one ammeter, and these are fast to the switchboard. We will assume that the voltmeter is a first class instrument, for if it is inaccurate, the compounding cannot be satisfactorily done. In such a case a voltmeter that is reliable must be borrowed or otherwise procured.

The first step is to determine how much the dynamo is to be over-compounded. To do this a flexible lamp cord must be provided, with a plug attachment at each end. It must be fifty feet or more long, for it will be necessary to string it from room to room about the building. This cord can probably be secured from the engineer's stock, and may consist of a number of cords pieced together; as it will only be used for this one purpose and then taken down, a coil of new cord will not be injured in the least by such service.

Select a circuit that runs to somewhere near the center of the system, and that has as few lamps on it as may be. Be sure that all of these lamps are turned off. Call this circuit *A*. It is evident that a suitable time must be chosen for this experiment, in order that the service be not interfered with. Start the dynamo and throw in enough circuits to give it a full load. The circuits should now be tested in order to ascertain the drop. To do this select any one circuit and make sure that all but one of the lamps are on. At this socket, which should be at a position about midway in the circuit under test, plug in the cord already described. Carry the other end of the cord to the nearest socket on the circuit selected first and plug it in there.

Returning to the dynamo room, take the terminals of this circuit, *A*, thus tied to the active circuit under test, and bring them down to a small switch, shown in Fig. 1. A double-pole, double-throw, baby knife switch will answer better than almost anything else. Of course, circuit *A* must not be thrown in on the bus bars.

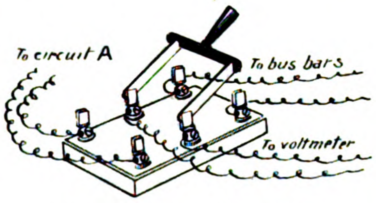


FIG. 1.—CIRCUIT SWITCH.

Make the connections as shown in the sketch, and the reading is ready to be taken. Be sure that the dynamo is fully loaded, and throw the switch on to circuit *A*. Note the voltmeter reading and by means of the rheostat adjust the dynamo voltage till the voltmeter reads the rated lamp voltage, say, 110 volts. Quickly reverse the switch, throwing it on to the bus bar, and it will at once be noted that the voltmeter reading rises. This reading should be carefully noted and recorded. Repeat the experiment several times, being sure that the reading from circuit *A* is always 110 volts, and thus assure yourself that the dynamo voltage did not vary while the readings were being taken.

One common error should be guarded against. The mean of several readings on a circuit will not give the best results. The difference in voltage sought is a definite quantity, and unless the conditions are altered, either by a change in the dynamo voltage while the reading is being taken, or the turning out of lamps on the circuit under test, the readings will be the same. Therefore, the reading that checks in greatest number, is probably the best, and should be used.

In a similar way the other circuits should be tested. It may be necessary to change circuit *A* occasionally, in order that the lamp end may reach from socket to socket, and in such a case the wires of the double-throw switch coming from circuit *A* may have to be crossed in order to make the voltmeter deflect the right way, for lamp sockets are wired without reference to positive and negative wires.

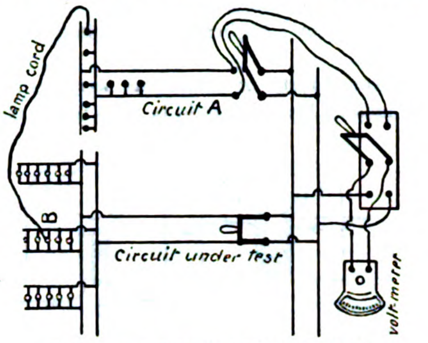


FIG. 2.—CIRCUIT CONNECTIONS.

The mean of the best readings of all of the circuits thus tested is the voltage that the dynamo should have at full load. The difference between this reading and 110 is the volts loss for which the dynamo is to be over-compounded, and the percentage this difference is of 110 is the per cent. of over-compounding. For the sake of a figure, say that this mean is 115. Then the dynamo voltage must be five volts higher at full load than at no load, for at no load the voltage should be 110.

It will be easy to see by consulting Fig. 2, that circuit *A* was simply a convenient means of connecting the voltmeter to the middle point of the circuit under test. Although circuit *A* may be made longer than the one that is tested, the current taken by the voltmeter is negligible, and the drop is practically the same as if the voltmeter were carried to *B* and there attached. This method of carrying the voltmeter about would be worthless, for while the change was being made the dynamo voltage would probably change.

Having determined just how much the dynamo is to be over-compounded, all is ready to undertake the process itself. There are two distinct ways of doing this. One is to wind on more wire than necessary, and reduce its effect by shunting, and the other is to wind on wire turn by turn till the desired result is secured. Although this latter process is by no means as laborious as would at first be imagined—for the number of turns that a good dynamo will require is very few—the method employing the shunt is to be preferred.

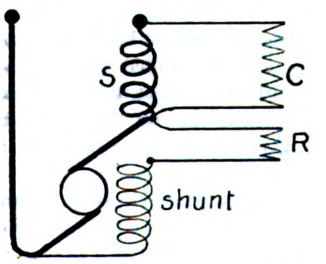


FIG. 3.—COMPOUND DYNAMO CONNECTIONS.

With the method using no shunt, the coils must be put on one after another, and coiled loosely about the field magnet till the proper number has been found. They must then be wound tightly on in a neat permanent job. With the shunt method the coils are tightly and permanently wound on in the first place, and the length and thickness of the shunt is varied to obtain the result. This method has the added advantage, that at any time the machine can be adjusted to suit any line loss, within reasonable limits, without rewinding. In fact, the shunt method is so far superior that it only will be described here. The other can be practiced if desired by any who understand the shunt method, for aside from the means of variation of the compounding, the methods are alike. It may be added that if varying the turns is used, it is better to use flexible cable than stiff wire.

The connections of a compound dynamo are shown in Fig. 3. The only difference between a compound dynamo and shunt dynamo is the addition of a series coil, *S*. The shunt, *C*, is used to deflect more or less current from the series coil, and its construction will presently be described.

The first thing to do is to wind the coarse wire on in such a way that it will correspond in its magnetizing power to the shunt coil. It is to be understood that however it may be wound on, it can be connected so as to be electrically correct, but might cause the connections to be unsymmetrical, and introduce too many wires about the machine. It is more workmanlike to ascertain beforehand exactly how things are to come, in order that the most simple arrangement of connections may be employed.

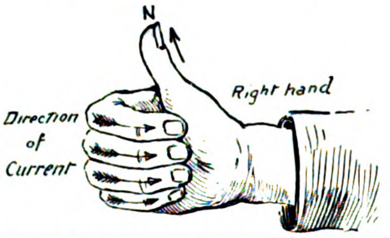


FIG. 4.—SHOWING DIRECTION OF WINDING.

It is customary to have the series coil on the positive side of the machine. Therefore with the voltmeter, determine which side of the machine is positive, and with a compass determine which pole is north, the north pole of the dynamo being that which repels the north pole of the needle. The direction of the winding on any magnet limb may then be determined by placing the clenched right fist alongside the bobbin with the thumb pointing toward the north pole. The fingers will then indicate how the current should flow, as shown in Fig. 4. Remembering that the current enters the series coil from the positive pole, and emerges therefrom at the positive terminal of the machine, the rest should be easy.

There are several important points to be kept in mind in winding the coils on various forms of field magnet. In machines having more than one magnetic circuit, whether bipolar or multipolar, the series coils should be wound equally over each of them. It will also be well to remember that it makes no difference where on the magnetic circuit, the coils are wound. They may surround the yoke piece or the shunt bobbins with identical results.

Fig. 5 illustrates a number of common types, showing where series coils may be wound. *a*, *b*, *c* and *d*, of Fig. 5 are single magnetic circuits. On such circuits it matters not where the coils are wound. They may even be wound out of balance, as in *c*, and yet not sensibly affect the result. Such cases as these are the simplest that will be encountered.

The forms of field magnets shown in diagrams *e* and *f*, must be wound with more care. In the case of *f*, the number of coils on each spool must be the same, for if as shown, with five coils on one side, and three on the other, the two magnetic circuits would not work in harmony. When running two machines in parallel, they must have the same potential, and similarly, when two magnetic circuits feed the same pair of pole pieces with lines of force, they must have the same *magnetic potential*, and in such cases as those just shown, the only way to secure this is to equalize the number of turns on each magnetic circuit.

If the machine be wound as in *e*, the coils surround the resultant magnetic circuit, or the part that is common to both. They therefore do not need to be exactly equal in number on the two pole pieces. However, if they are equal the field is a little more symmetrical, and for the sake of mechanical symmetry, an equal number of coils is advisable. It may be noted that in the cases of *e* and *f*, a turn is twice as effective when placed as in *e*, than it is when placed as in *f*. Theoretically it is twice as long also. Types *g* and *h* are common ones, and may be considered as two magnets acting on the same pair of pole pieces. They must be equally wound with series coils, whether the latter are wound on the yokes as in *h*, or on top of the shunt coils as in *g*. Types *i* and *j* are simply *e* and *f*, modified to multipolar forms, and the same remarks apply as regards balance and relative effectiveness of the positions of the coils. If these diagrams are carefully studied, there should be no difficulty in solving other problems that may arise.

Having determined how the wire shall go on, the next thing is to decide how much to put on, and this must in a measure be a matter of estimate. If the machine can be regulated from no load to full load with a few buttons of the rheostat, it is probable that but few series turns will be actually necessary. If, on the other hand, the rheostat requires to be cut out to a great extent for regulation purposes, it is likely that a goodly number of series turns will be needed. Of course this estimate is modified by the kind of rheostat, and whether the resistance cut out per button be large or small in number. If the number of shunt turns are known, the number of series turns can be exactly determined by experiment.

It is an excellent idea to secure some flexible cable and wind it loosely about the magnets, connecting it in series with the machine. If, as we assumed, the machine is to vary in voltage from 110 at no load to 115 at full load, the turns should be wound on, till the machine does this without touching the rheostat. This gives the exact number of turns that would be required. Take for instance the case of *b* (Fig. 5). Suppose that in the preliminary experiment just cited, ten turns were found to be sufficient to accomplish the result. By measurement eighteen turns would just fill one layer across the spool. It would then be advisable to wind on the full eighteen turns, for it would make a neater looking job and give a nice margin in case the machine needed to be compounded for a higher rise in voltage at any time.

Even if forty or fifty turns were required to make a layer it would be well to put them on, for the job would be much more symmetrical, and the added expense would be trifling, unless the machines were very large. A fraction of a layer on the top of the shunt bobbin gives it the appearance of an amateur's job.

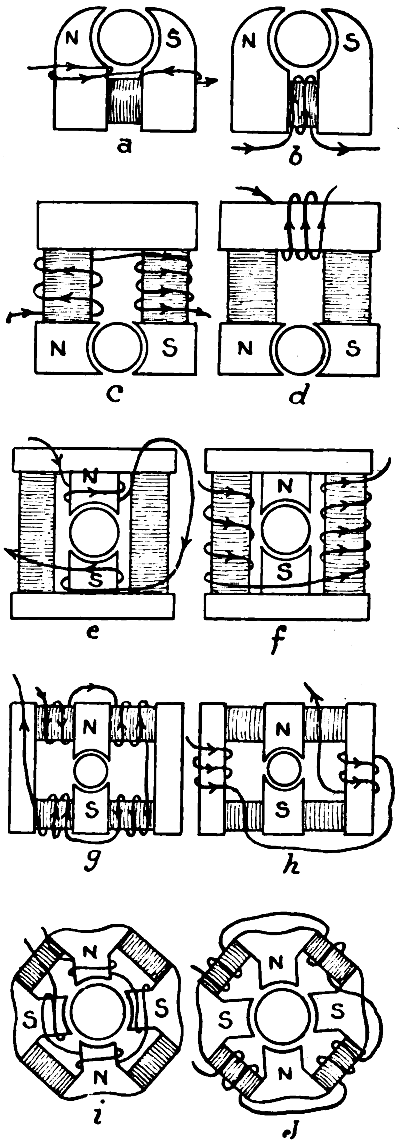


FIG. 5.—COMPOUND WINDINGS.

If the wire be wound upon a separate part of the magnetic circuit, as in *a*, *b*, *e*, *h* or *i*, it is always better to wind them thus if possible, for otherwise the shunt coil is liable to be damaged in winding the heavy series wire upon it. In case the shunt spool is excessively long and it is desired to wind upon it the series coil, it will be found convenient to make the series coil of a number of finer wires in parallel rather than one large one. This has the advantage of being easier to wind and less liable to damage the shunt coil in winding, and also makes a broad conductor which covers the shunt spool very quickly, and does not involve so many extra turns. After a margin of ten per cent. of over-compounding has been reached, any extra turns should be avoided if this can be done without sacrificing the symmetry of the finished job.

The actual winding on of the coils should be carefully done. If the series wire is to be wound on top of the shunt coil, care should be taken that the latter is amply protected by heavy paper. In starting and finishing, the ends of the coil should be secured to the adjacent convolution by many turns of strong cord evenly wound over the two wires. The better way is to wind in a number of pieces of cord as the winding reaches the last turn and they will then be ready to knot together. The ends of the coils should be provided with terminal lugs securely soldered. These terminals can be bolted to corresponding ones from the dynamo binding posts with a single bolt, thus making excellent contact, or they may be bolted on to the terminal studs of the machine. Each bobbin should be so provided with terminals, and the convenience which will result whenever the machine is taken apart, will be appreciated.

Having completed the series coil, and properly connected it into circuit. it remains to adjust the shunt, and the work is complete. The shunt may consist of a number of German silver ribbons, and may be of sufficient area to carry three-fourths of the full machine load without overheating. It is connected as in Fig. 3, across the terminals of the series coils. Its sectional area is determined as already indicated, and it merely remains to determine its length. This is conveniently done by means of a hand vise. One of the ends of the shunt should be suitably prepared with a terminal, and bolted in position, to the terminal of the series coil electrically next the brush. The hand vise should be securely fastened to that terminal of the machine next the series coil. The free end of the German silver ribbon may now be clamped in the hand vise at various positions until the proper adjustment is obtained. The procedure is as follows:

Load the machine, and allow it to run till it has gotten thoroughly warmed up, and is practically at its running temperature. Then throw off all load, and adjust the voltage to 110. Be sure the speed is the rated speed of the machine. Allow the machine to be operated ten or more minutes till it has thoroughly adjusted itself to the conditions. It is often the case that when adjusted to voltage each adjustment will require to be changed shortly, owing to a sluggishness of the field magnets. Therefore, wait till the voltage has attained a steady value. This being done, load the machine to full load, being careful to keep the series field heavily shunted by a very short length of the German silver ribbon. Note the voltage. It will, probably, be only slightly over 110, and, possibly, less than that value. Throw off the load, and try again with a longer length of series shunt, and continue the process till the voltage at full load is 115, when the voltage at no load is 110. The shunt should now be cut off, and soldered to its proper terminal, and bolted in place. After carefully taping the shunt ribbon, the job is complete. It will, probably, be found convenient to fold the shunt ribbon zigzag on itself, as it will then occupy much less room,

A BIOGRAPHICAL HISTORY OF ELECTRICITY.

In the history of electricity, Galvani is usually assigned a place much beyond what the importance of his actual work justifies. His real claim to fame rests upon the inspiration which others, and particularly Volta, drew from his labors, and not upon his discoveries, which he entirely misconstrued, nor upon his theories, which were of the kind devised to fit facts rather than built up from facts.

Aloysius Galvani (1737-1798) was a professor of anatomy at the University of Bologna, a school whose medical course at several periods has held a commanding position in Europe. The usual date given for his celebrated discovery of muscular contraction produced by electricity is 1786, but researches in scientific archives at Bologna have shown that he began experimenting with animal electricity as early as 1771.

Popular fancy in the day of Galvani as at present, delighted in anecdotal accounts of discoveries, and in this case we are offered the choice of two stories. According to one account, while an assistant of Galvani was one day skinning a frog from which to make a soup for the professor's sick wife, the latter, who, it appears, was supervising the operation, noticed that when the scalpel touched a nerve, the frog's muscles were agitated. The discovery was at once communicated to the husband, who was thus led to the investigations which have rendered his name famous. Another version of this story credits the wife with having herself started the investigation by showing that the removal of a neighboring static machine did not affect the result—an experiment more feminine than logical in its conception.

Another story is that one day Galvani, after dissecting several frogs in order to study their nervous system, suspended the carcasses by copper hooks from an iron balcony, and noticed in doing so that when the nerves happened to touch the iron, there was violent muscular contraction. Like almost all similar stories connected with great discoveries or inventions, both the above tales are most probably apocryphal.

Galvani did not seize the significance of his discovery, as is evident from the theories he advanced to explain it. According to one theory, the motions of the muscles were the result of the union, by means of the "metallic arc," of an exterior or negative charge on the sheath of the muscle, with positive electricity proceeding along the nerve from its inner substance. He considered the charge to be a special or animal electricity secreted by the brain in the interior of the nerves. Another theory which he offered was that the muscles are a reservoir of electricity, and that each fibre represents a little Leyden jar.

These theories led to much controversy, in which Volta took the leading part, maintaining that the electricity was of the ordinary kind and produced by metallic contact. The memoir which Galvani subsequently, in 1791, published, giving an account of his discovery, caused Volta to take up the subject of electricity, and subsequently, to his invention of the voltaic battery, from which invention modern electricity dates.

A name, until recently little known in connection with early work in electrical science, is that of Henry Cavendish (1731-1810), of whom Sir Wm. Snow Harris, one of the founders of the science of terrestrial magnetism, gives the following estimate:

"Cavendish had really anticipated all those great facts in common electricity which were subsequently made known to the scientific world through the investigations of Coulomb and other philosophers, and had also obtained the more immediate results of experiments of a more refined kind instituted in our own day." In the above comparison, "our own day," refers to the first third of the present century, and should be accepted as applying rather to refined experimentation than to original discovery.

ALOYSIUS GALVANI.

Cavendish made measurements on the relative conductivity of materials, and found iron to be 400,000,000 times a better conductor than water. This result does not agree very well with modern determinations (being about 1000 times too small), owing, probably, to impurities in the water used by Cavendish. The merit of the work of Cavendish, however, lies in its anticipation of the scientific methods of to-day. Lord Kelvin has said: "We do not know a phenomenon until it is possible to express it in numbers," and Cavindish was the first to extensively submit electrical phenomena to numerical determination, having preceded Coulomb in this direction. It was not until the publication of his papers by the late James Clerk Maxwell that the highly scientific character and great extent of the work of Cavendish became known.

Cavendish investigated the condenser and found that its capacity is proportional to the surface and inversely proportional to the thickness of the dielectric. He also employed the static spark in determining the relative proportions of hydrogen and oxygen in water. Exploding, by electrical means, various mixtures of these elements (of which the latter had just shortly before been discovered by Priestley) he exactly determined the present known proportions.

As an eccentric character, Cavendish is one of the most curious figures in scientific history. The grandson of two dukes (Duke of Devonshire and Duke of Kent) and immensely wealthy (he died worth $6,000,000—an enormous fortune for that period), he avoided all social duties and led the life of a recluse, scientific investigation apparently forming his sole pleasure. Being morbidly shy, he objected to any communication with female servants, and ordered his dinner daily by a note left on the hall table. Methodical in his habits, he never took a book from his magnificent library without leaving a receipt for it.

His scientific predilections led him to attend meetings of the Royal Society, of which he was a member, but apparently much to his discomfort, for we read that at such meetings "He shuffled quickly from room to room, seeming to be annoyed if looked at, but sometimes approaching to hear what was passing among others." It has been said of Cavendish that "He probably uttered fewer words in the course of his life than any man who ever lived to four-score years, not at all excepting the monks of La Trappe."

Though not coming within the scope of these articles, two names belonging to the period here considered may be mentioned on account of their ephemeral connection with electricity—those of Robespierre and of Marat, the victim of Charlotte Corday.

In 1783, Robespierre, then a lawyer practicing in his native town of Arras, France, was retained to defend on appeal a suit brought against a landed proprietor who had erected lightning rod on his house. The use of a lightning rod to avert the fire of heaven was considered impious by neighbors, who were also scandalized at this attempt to put into practice the teachings of natural philosophy, then as later considered to conflict with Christianity. The lightning rod was ordered to be destroyed, but Robespierre obtained a reversal of this decision.

At the recent National Electrical Exhibition in New York, the magnificent Benjamin collection of rare books, there displayed, relating to electrical science contained a volume written by Marat, the translation of the title being "Research on Electricity." The volume shown was presented by the monster of the Reign of Terror to the Comte d'Artois, a member of the French royal family whose reigning head he subsequently brought to the guillotine. Dr. Benjamin states that the book is peculiar for the looseness of its statements and for the impudence of the claims which the author makes to the discoveries of other people.

LESSONS IN PRACTICAL ELECTRICITY

In the August number it was shown that a single wire moving in the air-gap of a bipolar field, has generated in it an alternating E. M. F., and it should be added that in all commercial machines now in use an alternating E. M. F. is thus produced in each single wire: the commutator of a direct-current machine by combining these alternating E. M. Fs. of each wire produces a constant E. M. F. In the illustration of the cutting of the lines of force of the earth by the axle of a railway train, we have an example of the direct production of a constant E. M. F., and so-called mipolar dynamos similarly produce a constant E. M. F. directly without the intervention of a commutator; this latter type of machine, for reasons that will be given later, has received no commercial application except for electro-depositing purposes, requiring a very low voltage.

In order to produce directly a constant E. M. F., it will be easily seen that a wire must always cut lines of force in the same direction, as in the example of the train axle, and this demands a continuous field or its equivalent. In all commercial machines, the wire cuts the lines of force alternately in one direction and then in the other, thus producing an alternating E. M. F. In order that this alternating E. M. F. may increase and decrease gradually, the motion of the wire or, in an alternator, the proportioning of the coils and fields, is such as to approximate to a sine curve of E. M. F., such as in Fig. 2. In the August number it was shown that the revolution of a wire in a bipolar field naturally produces a sine curve of E.M.F.

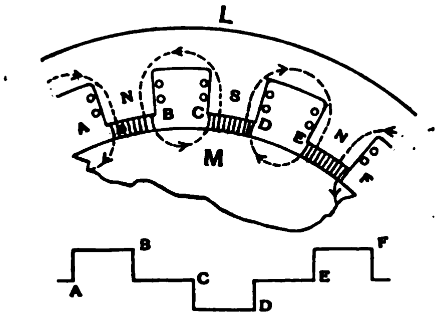
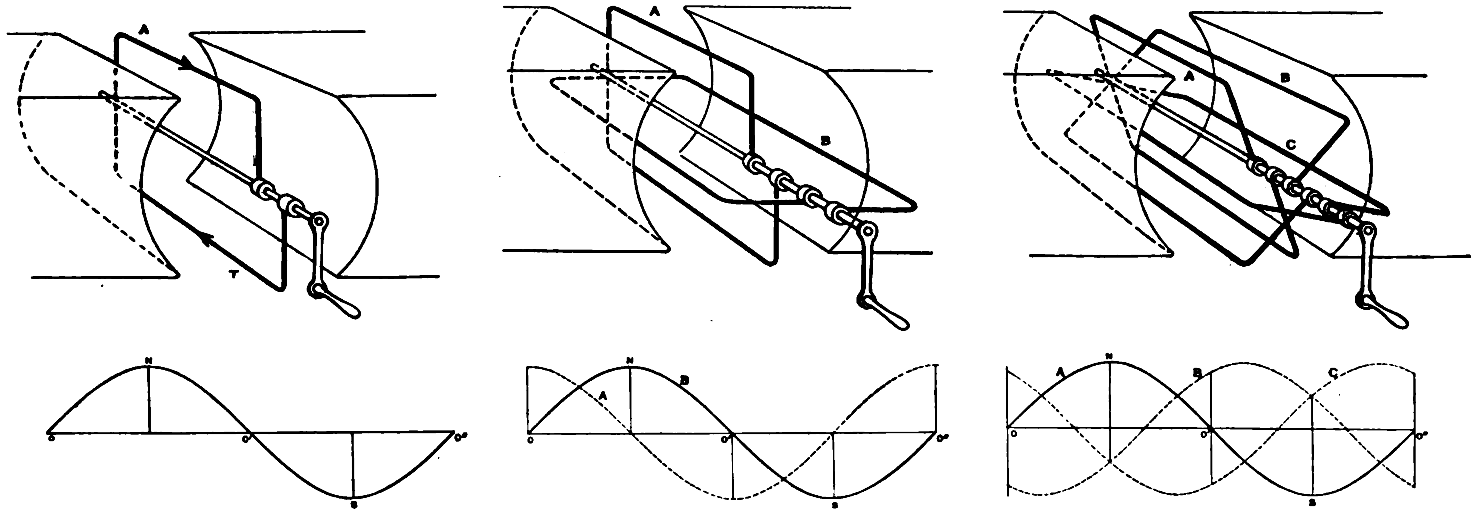


FIG. I.—DIAGRAM OF ALTERNATOR.



FIGS. 2, 3 AND 4.—SINGLE TWO-PHASED AND THREE-PHASED ALTERNATING GENERATION.

Referring to Fig. 1, L represents the field frame of an alternator, S and N being the poles. M is the armature, and the directions of the lines of force are shown by the arrows. It will readily be seen that an air-gap field, A B, corresponds to one of the two air gaps of a bipolar machine, as in Fig. 2, and C D to the other; and that if there are twelve pairs of poles, there will be in one revolution as many alternations as in twelve revolutions of the wires of a bipolar machine. It has been seen, however, that a wire moving in a bipolar field naturally generates a sine E. M. F., but in the case of Fig. 1 the variation of E. M. F., as shown in the lower diagram, is quite different. The wire upon entering the field at A immediately enters a uniform field, cuts lines at the highest rate and continues to do so until at B, when it becomes dead and remains so until C is reached; from C to D the lines run in the opposite direction, so that the E. M. F. is opposite in sign, and at D the wire become dead again, and so on. By having a number of wires in a coil, the form of the curve of E. M. F. is changed, and by a proper proportioning of the coil, poles and teeth (where the latter are used) any desired shape of curve may be obtained. Generally speaking, the sine form is most desirable.

The principles of the generation of E. M. F. by the the cutting of lines of force, above described, apply to all dynamos; there are numerous forms of windings for both continuous and alternating current machines, but these have reference to the manner of connection of the cutting wires among themselves and to the external circuit.

Fig. 2 represents a single dynamo coil in a bipolar field, the core being left out for convenience. As the upper and lower wires will cut lines in different directions the E. M. F. in one will be opposite to that in the other; it is evident, however, that they will add together so that between the collecting rings shown there will be double the E. M. F. generated with a single wire. It will also be seen that if the coil had ten convolutions instead of one, the E. M. F. would be ten times greater through addition.

Fig. 3 represents two independent coils at right angles to each other. Each coil will generate an E. M. F., but since when one is vertical or at position of no E. M. F., the other is horizontal, or at position of maximum E. M. F., the coils will, at the same instant of time, have different values of E. M. F.; that is, the two E. M. Fs. will not be in phase—which means that they have not the same value at the same instant of time—and the sketch thus represents a two-phased machine. In practice the windings are not entirely separate as here shown, but the principle remains the same.

Fig. 4 represents three independent coils equally spaced. As in the case of Fig. 2, each coil generates its own E. M. F., the value of which at any one instant of time, is different for each coil—or the sketch represents a three-phased machine. For reasons that will be apparent later, the two separate currents of a two-phased machine may be distributed by means of either four or three wires, and the three separate currents of a three-phased machine are distributed by three wires.

Going back to the generation of a single alternating E. M. F., and referring to Fig. 2, it will be seen that when the coil A T is vertical, no lines are being cut, which corresponds to the point O on the curve below; when the coil is horizontal, it is cutting at a maximum rate, which corresponds to the point N of the curve; when vertical again and A is at the lowest point, no lines are being cut, corresponding to the point O'; when horizontal again and A to the left, the coil is again cutting at a maximum rate, but in a direction opposite to that of the former horizontal position, thus generating a negative maximum E. M. F., corresponding to S; finally, at O'', zero E. M. F. is again reached, when another and similar cycle is commenced, and so on.

Now referring to Figs. 3, representing two-phased generation of E. M. F, it will be seen that when A is at the zero point of cutting, or O of the curve, B is at the maximum point; when A is at N, the maximum point, B is at zero, and so on.

Three-phased generation is represented in Fig. 4. Here it will be seen that when A is at the zero point of cutting, C has passed the maximum positive point of cutting and B is approaching the maximum negative point.

Letters from Practical Men

A Queer Phenomenon.

We are informed by Mr. Nikola Tesla that the peculiar phenomenon which Mr. R. T. Kenyon described in our August issue—a wire giving off light when excited from a static machine—is a well-known form of brush discharge which he has described repeatedly. Prof. Reginald A. Fessenden writes as follows: "Any wire, unless highly polished or covered with a perfect insulator, will appear luminous in the dark if its potential be raised to about 20,000 volts. If the line were broken and well insulated from the ground and the static machine gave a $\frac{1}{8}$ in. spark, we would have the phenomenon described. It is, of course, possible to see how resonance could produce a similar effect, but the above explanation seems the more natural and probable."

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Patent Law.

Your editorial in the August number brings up the reflection whether any patents at the present day can be said to possess value in view of the innumerable conflicting opinions of the courts. I venture to say that for every adjudication in favor of any important principle in patent law, another may be found contradictory. This unsatisfactory state of affairs seems to be the result, partly at least, of the ownership of patents by grasping monopolies, which has led the courts to stretch in favor of the public, the law intended to protect the inventor. While the immediate results of decisions rendered in this spirit may be favorable to the public, their effect is to discourage invention, and thus sooner or later injure the public. This seems to be the condition toward which we are rapidly traveling, and the litigation during the past ten years between the great electrical companies is largely responsible for it.

G. M. Thomas.

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Equalizer of Compound Dynamos.

In operating compound dynamos in multiple it seems to me that not nearly enough care is taken in the installation of the equalizer circuit. It is frequently of wire that is much too small, for it theoretically should have no resistance. When an equalizer switch is installed, a resistance is thereby introduced which is a very large percentage of the total resistance, and must affect the mutual action of the machines. If we must have equalizer switches, they should, in my opinion, be made to have a much more substantial contact than the ordinary jack-knife switch jaw. I would suggest a substantial mercury contact, such as is used in controlling currents on storage battery switchboards.

On some equalizer wires that I have encountered in the course of my experience, I have found *fuse boxes* installed! When the equalizer is carrying a current that is liable to overheat it, and, as is evidently supposed, then needs the protection of a fuse, that is the very time when, by all means, it should remain intact. Its failure would mean the almost instant reversal of current in the dynamo to which the equalizer is feeding current.

C. L. Tryon.

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Cutting Action of Steam and Gases.

In reply to N. R. Ripley in your July issue, I wish to call his attention to the fact that the friction between air and other gases and solids or liquids is very great. It is on account of this friction that we have such enormous waves at sea during gales of wind. The film of oil which reduces the breaking of the sea seems to act not only by its cohesion and deadening action upon the water, but by having a less amount of friction with the air. Be that as it may, however, air, steam and most of the gases with which I am acquainted have a great deal of friction with solids. When under pressure this friction is increased, and if the gas is escaping through a small orifice the law of friction in regard to speed while pressure and surface remain equal stills holds true. It is a fact of long observation that the small valves of a certain kind of steam drips cut with great rapidity if allowed a very small rise or opening.

Whether it is possible for a leaky valve or valve stem to experience such a cutting action as to cut out the whole of the metal and leave nothing behind, is something that I will not attempt to answer. That steam flowing through a small orifice can cut most desperately is a fact. It might also have been possible that there was galvanic action set up and that the first leak was caused by this action, brought on by the presence of water of condensation in the valve. That steam cuts, and cuts like a knife, especially when the pressure is high and the outlet small, is a fact tolerably well established and known to most old engineers.

Pittman.

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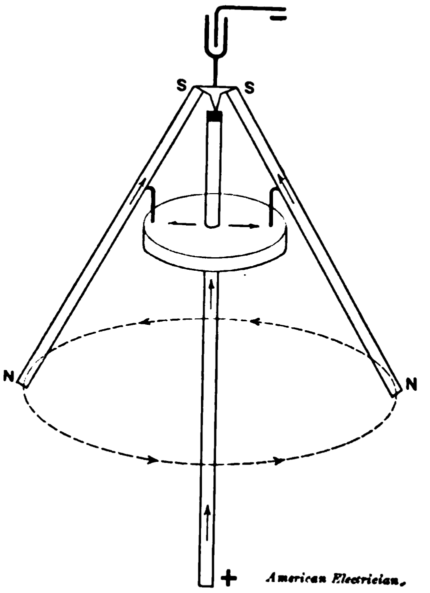
A Suggestion for an Instructive Experiment.

Text books state that a single north pole would be propelled continuously along the whole circuit of a magnetic line of force in the direction from north to south. They also state that a single north pole may be approximately represented by the pole at the end of a long bar magnet. As an experimental proof of a statement always leaves a much more lasting impression, the following simple experime[illegible]gested itself to the writer; it is a mere suggestion, however; the writer has not tried it and cannot vouch for its success, and it even seems as though there may be a fallacy somewhere.

Two long thin steel magnets, *NS* and *NS*, are secured, as shown, to a pivot resting on the top of a vertical copper wire, but insulated from it; a mercury cup is situated over the pivot; contacts and a mercury trough connect with the vertical conductor as shown, leading the current from the mercury cup at the top to the conductor. If now a strong current is passed as shown, through the conductor, circular lines of force will be generated as indicated by the dotted line.

If the text book statements made above are correct, it seems that the north ends of the magnets should then move along the lines of force, and the whole of the movable part should therefore revolve in the direction indicated. As the current in the upper portion of the movable part flows through the movable part itself, no effective propelling action can exist there, tending to move the south poles in the opposite direction, which it would do if the pivot was not insulated from the conductor.

If it is possible to generate such lines of force (which make a complete circuit in the air without any mechanical obstruction), by any other means, the experiment might be simplified. Do such lines exist in the air space enclosed by an iron ring wound with a coil of wire? If so, would they also exist if the ring were a non-polar steel magnet instead of an electromagnet? An approximation to such a field would certainly exist if four bar magnets were placed so as to form a square with a pair of unlike poles at each corner. In that case it would be interesting to explain why such a system would not be of perpetual motion, as there should then be continuous motion produced by a combination of permanent magnets only.



The latter deduction leads one to believe that there may be a fallacy in the principle of the experiment shown in the illustration; or else it shows that the text book statements made above should be modified, limited or explained more clearly.

A simpler way to show the movement of a north pole in the direction of the lines of force is by the deflection of a compass needle when placed in a magnetic field. But would it not be much simpler to explain this by saying that lines of force tend to become parallel to each other, instead of involving the impossible conception of a single pole and a motion along lines of force? Abstract statements have their value, but elementary text books should be as free from them as possible.

The movement of a pole along a line of force might be illustrated by placing two bar magnets perpendicular to each other, when they will tend to become parallel, but this simply demonstrates the elementary rule that two unlike poles attract each other, or that lines of force shorten their path, but it does not prove that a single pole would move continuously over the circuit of a line of force.

Electrician.

ELECTRICAL CATECHISM

44. What remedy should be applied when a dynamo becomes reversed?

Reverse the residual magnetism by current from another machine or from a battery. If this is not convenient, the connections between the machine and the line may be transposed or crossed, so that what was formerly the positive terminal of the dynamo, but is now the negative terminal, will be connected with the negative line terminal and *vice versa*.

45. Cannot the dynamo be reversed by reversing the connections between the armature and field?

No, for then the machine could not build up. (See No. *34*.)

46. Will a dynamo pick up if the armature rotates in the opposite direction?

No. Because by reversing the direction of rotation, the voltage due to the residual magnetic field (see AMERICAN ELECTRICIAN June, 1896, page 68, No. 11) is reversed and sends a current through the field coils in the wrong direction so that the dynamo cannot build up.

47. What changes must be made if it is necessary to run a dynamo armature in the opposite direction from what was intended?

The connections between the armature and the field terminals must be reversed so that the initial current will go through the field coils in the right direction (see No. 34 AMERICAN ELECTRICIAN Aug., 1896, p. 140., and No. 46 above).

48. What is to be done if the brushes suddenly begin to flash or spark excessively?

Look first at the ammeter or current indicator to see if the machine is delivering too much current. Then see if the brushes make good contact, since the springs or brush holders sometimes get loose. Then see if the commutator has a high bar or a low bar.

49. What can one do if the dynamo is giving too much current?

If the current is more than twenty or thirty per cent. above the rated capacity of the dynamo and if it continues more than a few minutes, the main switch should be opened. If the machine is supplying lights whose sudden extinction might cause a panic and endanger human life, one should risk injury to the dynamo rather than to life. When it is unsafe to shut down, the dynamo may be relieved by changing the regulator so as to lower the voltage until the lamps give only a dim light. The current will decrease with the voltage.

50. How can one avoid an excess of current?

All parts of the circuit should be protected by safety fuses of suitable capacity so that any branch taking too much current will be cut off automatically by the melting of the fuse and consequent opening of the circuit.

51. If a plant has no ammeter or current indicator, how can the attendant tell when a dynamo is delivering too much current?

In a well made modern dynamo, no part should get too hot to be touched by the hand after the dynamo is shut down. If the armature begins to smoke or if it smells strongly of shellac, it is carrying an unsafe current. So long as the armature does not get uncomfortably hot during the regular run, the load is within safe limits.

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Frequency Indicator.

Mr. Albert Campbell in the London *Electrician* describes a simple instrument for determining the frequency of the alternating current, the operation of which will be understood from the accompanying illustrations.

In Fig. 1, *AB* is a steel strip or reed which, by means of suitable gear, can be moved in either direction through the clamp, *C*; a rack and pinion connected with the end, *B*, operates a pointer which indicates on the scale of the instrument the variations in the length of *AC*, the vibrating portion of the reed. Near the vibrating portion, *AC*, of the reed is fixed an electromagnet, *M*, having a well laminated core excited by a small current derived from the alternating circuit to be tested. The length of the portion, *AC*, is regulated by means of a milled head, shown at the top of the case in Fig. 2, until the reed is thrown into strong vibration by the field due to the electromagnet, *M*. This takes place when the vibrating portion of the reed is of such length that it naturally vibrates with a frequency double that of the frequency of the alternating current in *M*, this resonance being indicated by the loud note given out. The exact point of maximum resonance is more easily observed by using an adjustable part, *P*, which can be so set that it jars against the vibrator only when the latter reaches its greatest amplitude.

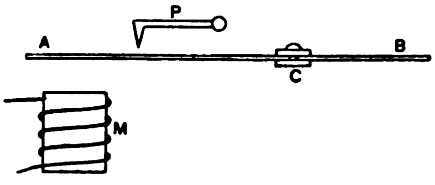

FIG. 1.

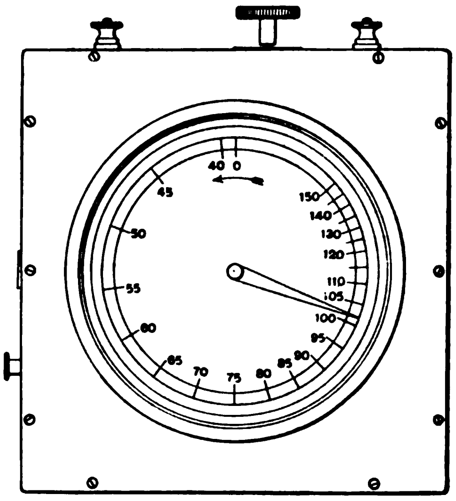

FIG. 2.

Fig. 2 gives an exterior view of one of the instruments, the range of which extends from 40 to 150 periods per second. The milled head at the top is, as stated before, turned until a loud note is obtained, when the frequency is read off directly from the dial. The adjustment can be made in a second or two, so that the instrument may be used to follow quick changes in the frequency. By means of the milled head at the side, the jarring piece, *P*, can be so adjusted as to enable sharply defined readings to be taken. The inventor states that it is easy to obtain readings correct to less than one-half per cent.

Since the instrument works with unidirectional pulsating currents as well as with alternating ones, it can be used as an accurate speed indicator for high speeds; for this purpose a commutator is mounted on the shaft whose speed is required to be known, and a direct current made and broken by this commutator is led to the instrument, which may be situated at a distant point.

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Resistance of Rail Joints.

Some interesting results of the measurement of rail joints are given in the *Street Railway Journal*, by Mr. Richard McCullough.

A number of cast joints on eighty-five pound, seven inch Johnson girder rail were measured with different amounts of current. The resistance for the different joints calculated from this ran very uniformly, averaging 0.0000172 ohm, the highest being 0.000020 ohm and the lowest 0.000014 ohm. In order to compare this with the resistance of an equal length of the rail itself, nine rails, varying in length from thirty feet to sixty-two feet, were brought into the shop and tested in the same manner. Five of these were eighty-five pound, seven-inch rails and the others were of a smaller section. The results checked up very closely, and averaged for the seven-inch rail, 0.0000102 ohm per foot of rail on 86.61 ohms per mil foot.

The resistance of fourteen inches of rail calculated from this is 0.0000119 ohm, and comparing this with 0.0000172 ohm, which is the resistance of a fourteen inch cast joint, it is evident that the resistance of a cast joint is forty-four per cent. greater than the same length of rail. The resistance of a track laid with this cast joint will be only slightly greater than the resistance of the rails themselves, because if the track is laid with thirty-foot rails, the length of the joints will be four per cent. of the length of the rails.

A number of rail ends were bonded with some of the ordinary bonds in use and their resistance measured in the same way. As these bonds were of several different lengths and sections, from their resistances the resistance of the copper wire was deducted, leaving only the resistance of the contacts. The lowest contact resistance obtained in this way was 0.00004 ohm, which alone is two and one-half times the total resistance of the cast joint. All of the bonds tested were new, the contacts bright, and the bonding carefully done in the machine shop.

QUERIES AND ANSWERS

How much calcium tungstate is required for a 6 in. × 6 in. Röntgen screen, and what will it cost? D. E.

One-eighth of an ounce of Mercks' calcic tungstate is sufficient; the price is about $1.25 per ounce. The tungstate should be on the inside surface of the screen.

Please give a simple way of finding the direction of current in an arc circuit in order that a lamp may be correctly cut in. S. L. K.

A simple method was given in this department in the June issue, but the practical way to find the proper connections for an arc lamp is to place it in circuit; if then the crater burns in the lower carbon, reverse the binding post connections.

How can I tell exactly how much current and energy are wasted from a line or other electrical circuit through grounds? ENGINEER.

The article by Prof. McKissick in another column shows how the insulation resistance may be determined. Dividing the voltage by the insulation resistance gives the loss of current. Multiplying the current thus found by the voltage gives the loss in watts.

Can the increase in voltage of a dynamo resulting from an increase of speed be determined from the revolutions?. W. P. S.

Not with any accuracy in the absence of a characteristic curve, unless both the field and the armature reaction remain the same; that is, unless the ampere turns in the field coils and the current through the armature remain unchanged. In any practical case, the ampere turns at least would probably be changed, and there is no method of calculating the resultant change of the field owing, in the case of commercial machines, to the absence of data.

How do you make a spark coil for electric gas lighting? M. J. S.

Make a core ¾ in. in diameter and 8½ ins. long, of soft iron wire of the smallest size available. It may be well to anneal the wire before cutting by bringing to a red heat and allowing it to cool very gradually. Form a spool by slipping on each end of the core a disk of ½ in. wood, 2½ ins. in diameter. Tape the core and wind on seven layers of No. 14 cotton-covered magnet wire, bringing an end through a hole in each disk; 3½ lbs. of wire will be required. Tape the coil and wind on neatly a layer of twine, and then shellac.

Please explain the condition of two or more generators working in multiple. How can the E. M. F. of one be raised to regulate its load, without disturbing the others? A. V. Y.

The condition of two or more generators working in multiple is difficult to describe in limited space. The ideal condition is one where all the machines are generating exactly the same E. M. F., in which case the total load will be equally divided between the various machines, provided the armatures of all are identical as to resistance. The moment one machine fails to generate the full E. M. F. required, the superior voltage of its mates forces over more than its quota of the load, and to restore equilibrium the E. M. F. of the failing machine must be raised until it again equals that of its mates. The E. M. F. of one of a group of generators is never raised to regulate its load except when the equilibrium has been previously disturbed by its voltage falling below that of its mates.

Referring to Lessons in Practical Electricity, page 98, "drop or line loss" is mentioned. Is the amount of this arbitrary as to length of line, or how is it calculated? S. P. A.

Usually the drop is assumed, and refers to the extreme variation of voltage permissible. In house wiring, for example, the maximum drop is five per cent. For important transmission lines the line loss or drop is calculated; it is apparent that the smaller the investment in copper the larger the line loss, and by calculation a line loss may be found for which the sum of the annual fixed charge on the cost of line, and the cost of the line loss of electrical energy per year, will be a minimum.

1°. Will a secondary coil of a transformer having the same number of turns as the primary generate approximately the same E. M. F.? 2°. Why does increasing the primary turns lower the secondary E. M. F.? O. F. L.

1°. Yes, for the reason that each coil will, during an alternation, be cut by the same number of lines of force. 2°. Because the turns of the secondary coil will be cut by a number of lines of force less than before, and less in proportion to the increase of primary turns. This follows from the fact that the lines of force being inversely proportional to the primary turns, the impedance or resultant of resistance and inductance, will vary as the square of the turns, since the resistance effect is very small in proportion to the inductance, and the latter varies as the square of the turns. Consequently, if the turns are doubled, only about one-fourth the current will flow, and the ampere turns will be reduced nearly one-half; the flux will, therefore, be reduced correspondingly and, of course, the secondary E. M. F. in the same proportion.

Is there any general formula to determine the size and amount of wire and iron for a transformer? I wish to make a transformer of a capacity of ten watts on a 100-volt circuit. E. S.

There is no general formula, as too many factors of variable value enter. The number of turns of the primary wire depends upon the impressed E. M. F. and number of lines of force desired; the amount of iron depends upon the number of lines of force and working density; the number of turns of the secondary is less than that of the primary by the ratio of the secondary and primary voltages. An experimental determination for the above case will be most satisfactory. Make a ring of ½ in. section and 3 ins. diameter, of soft iron wire. For primary wind with sufficient No. 24 wire to keep primary current down to a point that the outside leads of wire will be but slightly heated. Wind the secondary with a size of wire corresponding to the current to be taken from it, the turns being according to the ratio given above, or determined experimentally. Another way to make a small transformer is to place one coil on the other and wrap both with soft iron wire.

In the August number, in answer to the query "The load being constant, why does the speed of a series motor vary directly with the applied E. M. F." it is said that, since $E—e$ is constant, the speed must rise in the same proportion as the applied E. M. F. Why is this so? E. L. R

Since E is the applied E. M. F. or the E. M. F. at the motor binding posts, and e is the counter E. M. F., the free voltage is $E—e$, and the current according to Ohm's law, is $\frac{E-e}{R}$, where R is the resistance of the motor. But it was shown that if the torque is constant, the current is constant, and as R is constant, $E—e=$ a constant quantity, which we will call a. Now e, the counter E. M. F., is the E. M. F. generated in the armature through its wires cutting the field in the same manner as a dynamo, and therefore its value will be the product of the speed, s, and the strength of the field, N; consequently $E—e=a$ becomes $E—s\,N=a$, or $s=\frac{E}{N}-\frac{a}{N}$. In most cases the second term of the right hand part of the equation may practically be neglected, so that $s=\frac{E}{N}$ or the speed varies directly with the applied E. M. F.

1. I find that in some cases the mixture of water and sulphuric acid for storage batteries is given in specific gravity and in other cases in degree Baumé. How are the two connected? 2. I also find that the specific gravity recommended for the mixture varies from 1.15 to 1.24. Which is the better practice?

1. The Baumé is an arbitrary scale with the following equivalents in specific gravity, and in proportions, by weight, of water and acid:

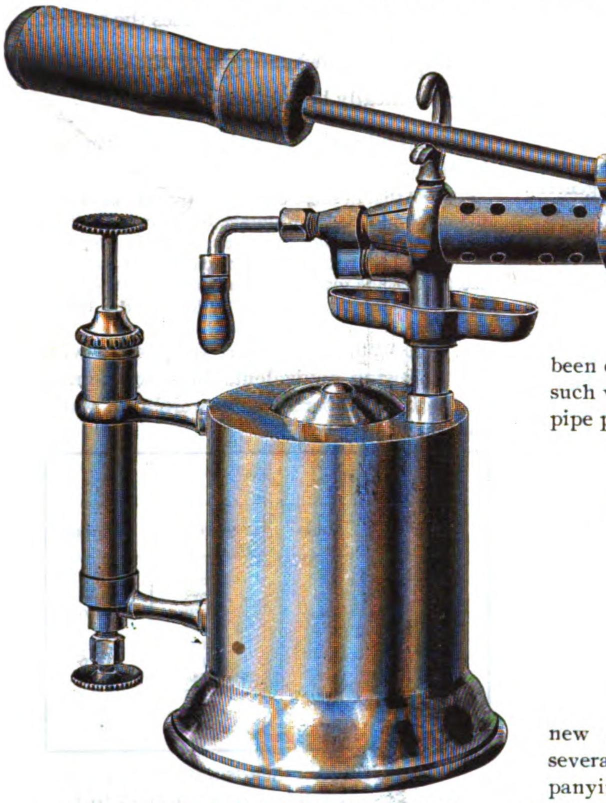
By Weight			
Water	Acid	Sp. Gr.	Baumé
10	1	1 062	8.7
9	1	1 068	9.5
8	1	1 076	10 6
7	1	1 088	12
6	1	1.101	13.7
5	1	1.118	16.6
4	1	1.144	18.5
3	1	1.182	22 5
2	1	1.248	29.5
1	1	1.398	41.7

2. Salomon recommends a mixture to start with having a specific gravity of 1.13 to 1.15 (17 degs. to 19 degs. Baumé, or about four parts, by weight, of water to one of acid), which become 1.18 to 1.20 (22 degs. to 25 degs. Baumé, or about three parts, by weight, of water to one of acid). The most desirable density to use largely depends upon the type of plate; from 1.180 to 1.200 is now accepted as the most desirable, everything considered, this being, of course, the maximum density when the cell is fully charged. If plenty of clearance is given to the plates so that there is ample electrolyte, 1.180 (22 degs. Baumé) is perhaps the most satisfactory. The Electric Storage Battery Company considers it desirable in all cases to have a sufficient volume of electrolyte that the density may not fall from full charge to full discharge more than, say, from 1.180 to 1.150. Any density over 1.300 (33 degs. Baumé) would be injurious, and the capacity is cut down enormously if this density is exceeded; 1.400 or 1.500 (42 degs. or 49 degs. Baumé) would certainly be very injurious to the plates, leaving out the question of capacity. The lowest resistance of the electrolyte is obtained at a specific gravity of 1.215 (25.2 degs. Baumé), above and below which density the resistance increases. The misapprehension in regard to the proper specific gravity of the storage battery electrolyte is probably partly due to the fact that the density of the mixture varies with the state of the charge, increasing as the battery becomes charged.

New Apparatus and Appliances.

HOT BLAST BLOW TORCH.

The combination hot blast blow torch illustrated herewith, is made after a new principle, by means of which a solid blue flame of intense heat is produced. To insure reliability, the manufacturers test every torch to thirty pounds pressure. The consumption of gasoline is 1½ pints in four hours steady burning. The torch has no wicking or coil to burn out, and the tank is made of one piece of seamless brass with a filler plug in the bottom. The torch shown is at once a brazer, blow torch, and, as indicated in the engraving, a soldering iron heater. This type of an electrician's indispensable appliance is made by the White Manufacturing Company, 40 State Street, Chicago, Ill.



COMBINATION HOT BLAST BLOW TORCH.

LEAD PIPE COUPLERS AND FITTINGS.

Each year the march of progress in the mechanical world steadily continues, and labor saving devices take the place of old, crude hand work. One of the latest ideas advanced in this connection is the use of brass couplers and fittings for doing all kinds of lead pipe plumbing work without the aid of solder or the necessity of "wiping" joints.

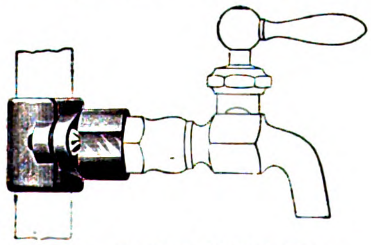


FIG. 1.—FAUCET CONNECTION.

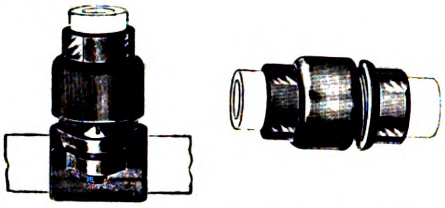


FIG. 2.—LEAD-TO-LEAD TEE AND COUPLING.

As a rule heretofore, engineers, steam fitters and in fact all mechanical trades have been entirely dependent on plumbers for such work as came under the head of lead pipe plumbing. The introduction of these new couplers and fittings, of which several forms are shown in the accompanying illustrations, obviates the necessity of calling for the plumber and using solder, thus placing lead pipe plumbing work that is in charge of the engineer in or around any power plant, completely under his control as are the other parts of his piping system. He may extend the same at will to any extent, or make repairs at any time or in any place; in fact do any kind of lead pipe plumbing in a strictly mechanical manner. The connections are easily and quickly made, as the illustrations indicate. One of these is to connect a faucet to side of lead pipe by boring a hole in the side of the latter and clamping the parts of the fitting together by turning up the side screws. This new system has been placed on the market by the manufacturers, Monash-Younker Company, 203 S. Canal Street, Chicago.

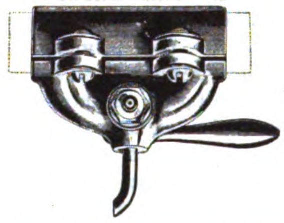


FIG. 2.—STOP AND WASTE.

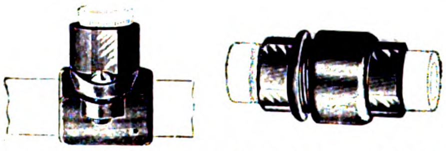


FIG. 4.—LEAD-TO-IRON TEE AND COUPLING.

MAIN LINE CUT-OUT.

During the past few years insurance inspectors have become more stringent with respect to circuit fittings, and the type of main line cut-out shown in the accompanying illustrations has been designed to obviate objections urged against the older forms.

Fig. 1 shows the cut-out complete and Fig. 2 with the cover removed. From the latter illustration it will be seen that the fuses are contained in separate chambers, *A A*. When the cover is in place a projection fits into the recess, *C*, thereby isolating each fuse and its connections in a separate chamber. The electrician will also note the convenient method of line connection, whereby the labor of connecting up is reduced. All parts of these fuse boxes, which are made by Pass & Seymour, Syracuse, N. Y., are interchangeable, which is a feature that will be appreciated by both supply dealer and contractor.

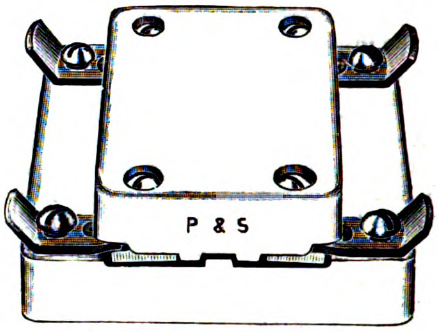


FIG. 1.—MAIN LINE CUT-OUT.

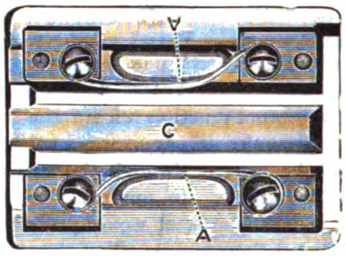


FIG. 2.—MAIN LINE CUT-OUT.

ALTERNATING CURRENT INSTRUMENTS.

The inclined coil type of measuring instrument developed by Professor Thomson, has been adapted for use on switchboards, and a complete series of these instruments is now being manufactured by the General Electric

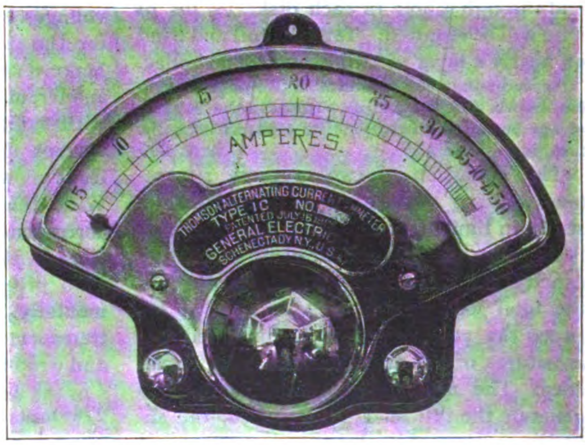


FIG. 1—THOMSON A. C. AMMETER.

Company. With the accuracy and durability of the portable appliances, they combine the long scale and general mechanical character requisite in modern switchboard practice. The instruments are free from parts liable to change and thus are permanent in their readings, and they are accurate with the same calibration for all commercial frequencies. Each instrument is constructed for either back or front connection, is fitted with a light nickel cover and binding posts and a black enameled metal base. The ammeters read from 0 to 3½, 10, 25, 35, 50, 75, 100, 150 and 200 amperes, and the voltmeters from 0 to 75, 150 and 650 volts. Fig. 1 illustrates an alternating current ammeter of this type, and Fig. 2 a switchboard panel showing a voltmeter and ammeter in place.

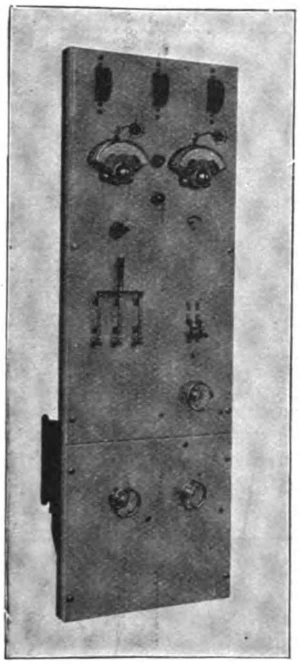


FIG 2.—SWITCHBOARD PANEL.

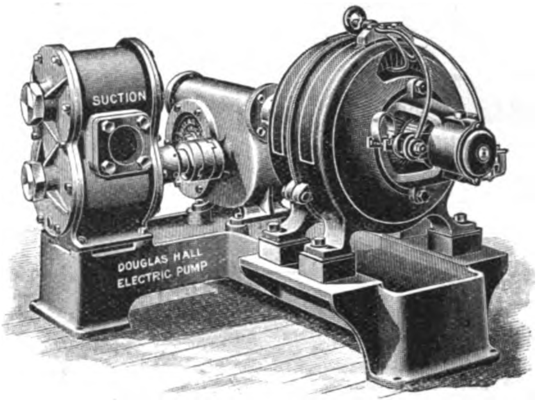
DOUGLASS-HALL ELECTRIC PUMP.

The electric pumping combination we illustrate has been designed particularly for maintaining a supply of water for house purposes, operating hydraulic elevators or for any service where it is desired to elevate or distribute water. The manufacturers were among the first to adapt the pump to the electric motor, and the present combination represents the result of an extended experience in this line of work.

Any form of electric motor can be used with the pump, that shown in the illustration being of the Lundell type. To the shaft of the motor armature is direct-coupled a two-part worm, one helix being right and the other left-handed; these mesh with two gears, to one of which the pump shaft makes fast. By means of this double worm gearing, end thrust of the worm is entirely obviated. The pump is of the rotary gear type, the action being similar in principle to that of the well-known Root blower. There are two wide gears, each having 12 deep teeth, the driving gear being of brass and the other one of hard rubber.

This, it may be remarked, is one of the oldest types of water pumps, its invention dating from the 16th century. In its original form a serious objection was encountered from friction and consequent wear, due to the reaction of the discharge pressure. In the present type this pressure is balanced by means of ports or radial openings between each tooth and extending through the gears, the discharge pressure being thus made to act on both sides of the gears, thereby perfectly balancing them. Owing to this ingenious method, the gears are subject to no grinding wear against the suction side of the gear case, and the bearings will run true indefinitely.

The pumping outfit includes an automatic starting rheostat operated by an electrical device at the receiving water tank. The pump described is the invention of Mr. M. W. Hall, and is manufactured by the W. & B. Douglass Company, 87 John Street, New York.



DOUGLASS-HALL ELECTRIC PUMP.

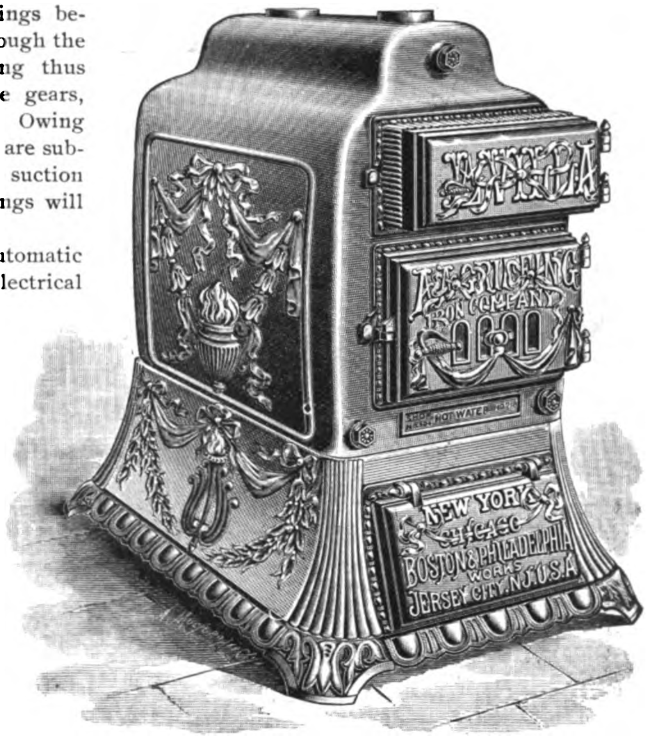
LA VILLA HEATER.

Apparatus for house heating usually does not display evidences of the highest skill in design and mechanical construction, doubtless owing to the fact that the ordinary purchaser of a heater is not a judge of these qualities. The reader will, however, recognize in the heater illustrated herewith an example that will withstand criticism, both with respect to mechanical execution and the economical production and utilization of heat.

Owing to the entire fire-pot being corrugated, a great amount of direct heat-absorbing surface is presented, and as the hot gases from the furnace have to travel three times the length of the heater before reaching the smoke-pipe, all of the useful heat they carry is taken up. The heater is equipped with a rocking and dumping grate, which will burn equally well soft or hard coal, coke or wood. The circulation in the boiler has also received careful attention.

Another important point that has been considered in its design is accessibility for cleaning; when both the front and rear cleaning doors are opened, every square inch of the heater is visible and easily accessible for cleaning, which is thus made a very simple matter. If a heater can be easily cleaned, the chances are that it will be frequently cleaned, and if kept clean the economy of fuel is very marked. The best heater made, if coated with the deposits of combustion, which are non-conductive in their nature, is, like a boiler, very seriously handicapped.

As will be seen from the illustration, the heater is ornamental in appearance. It is portable and easily set up, coming practically in three parts—base-plate, ash pit plates with grates in place, and heater proper. The heater is not designed for large buildings, but for the thousands of small buildings such, as cottages, small railway stations and office buildings, etc., for which its size, appearance and low cost make it an ideal apparatus.

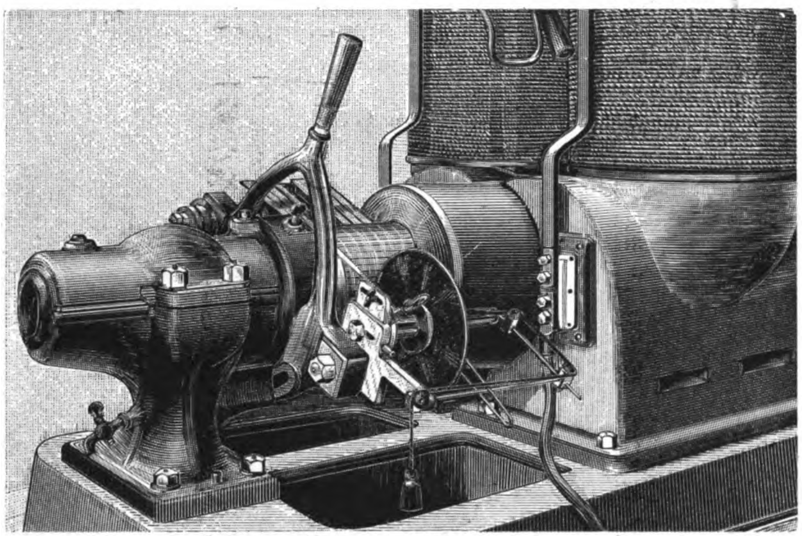


LA VILLA HEATER.

The LaVilla heater is made in ten sizes for steam and the same number for water. The manufacturers, the A. A. Griffing Iron Company, 66 Centre Street, New York, will send a descriptive pamphlet to readers who mention the AMERICAN ELECTRICIAN.

COMMUTATOR DRESSING TOOL.

The dynamo commutator dressing tool shown in the accompanying illustration is very simply attached to any type of dynamo or motor and enables a worn or roughened commutator to be quickly and accurately dressed. The tool is bolted to one of the dynamo brush rocker arms by means of a steel bolt. The plate which carries the bolt has a long slot in which is secured a spindle carrying a grinding wheel; the slot permits the spindle to be adjusted so as to enable any desired depth of cut to be taken by the wheel. The wheel itself travels along a sleeve on the spindle while making a cut, the sleeve being driven by a pulley to which motion is given by a belt from the iron collar on the end of the commutator. A feather in the sleeve causes the wheel to revolve with it; lateral motion is given to the wheel by hand as the cut progresses, or it may be fed automatically by means of a weight (shown in the illustration), which causes a gradual automatic feed motion across the face of the commutator.



COMMUTATOR DRESSING TOOL.

This simple and efficient dynamo attachment is made by Geo. P. Cummings, 1441 Broadway, New York.

ELECTRIC POWER COTTON MILL.

The cotton mills of the Pelzer Manufacturing Company, at Pelzer, N. C. (one of the largest in the world under one roof), have been completely equipped with electric power by the General Electric Company, the three-phased system being used, with generators driven by water power.

Five pairs of Victor wheels will be used, of which three pairs are now installed. Each pair of turbines is connected to the armature shaft of a 1000-KW, three-phased generator (Fig. 1), delivering current at 3300 volts when turning at a speed of 167 r. p. m. A plan of the generating room is shown in Fig. 2. The exciters are multipolar dynamos of the General Electric slow-speed type, and are directly driven by belts from the turbine shafts. The switchboard, of the skeleton type, located in the gallery, carries the special high tension switches, the synchronizers and usual rheostats and measuring instruments, the bus bars receiving the current direct from the generators without transformation, whence it is sent over a pole line 2⅝ miles long to the points of delivery.

In the larger mill there are nine transformers, three of which have a capacity of 265 KW and six of 275 KW capacity. They are of the General Electric air blast type, in which the principle employed to keep them cool is to send a constant current of air through the laminations by means of two electric blowers. In the transformers the pressure is reduced to 200 volts, at which pressure the current is brought to the motors. There are also two transformers reducing the current to 114 volts for the 1200 incandescent lamps used to light this mill.

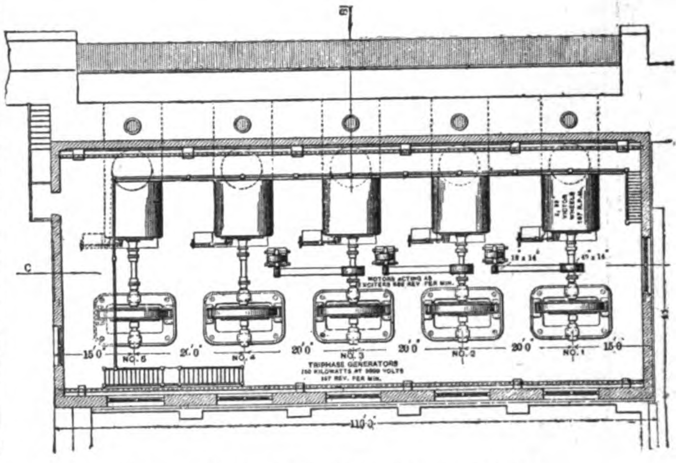


FIG. 2.—PLAN OF PELZER POWER HOUSE.

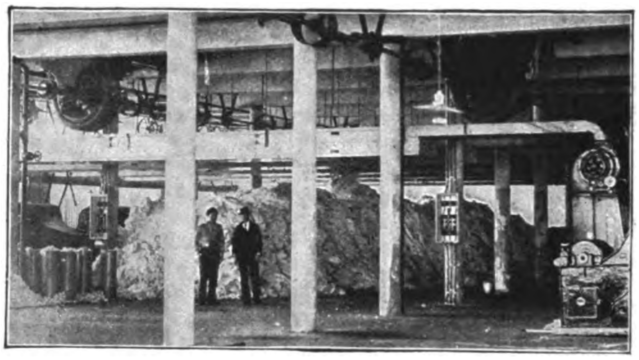


FIG. 3.—PICKER ROOM—PELZER MILLS.

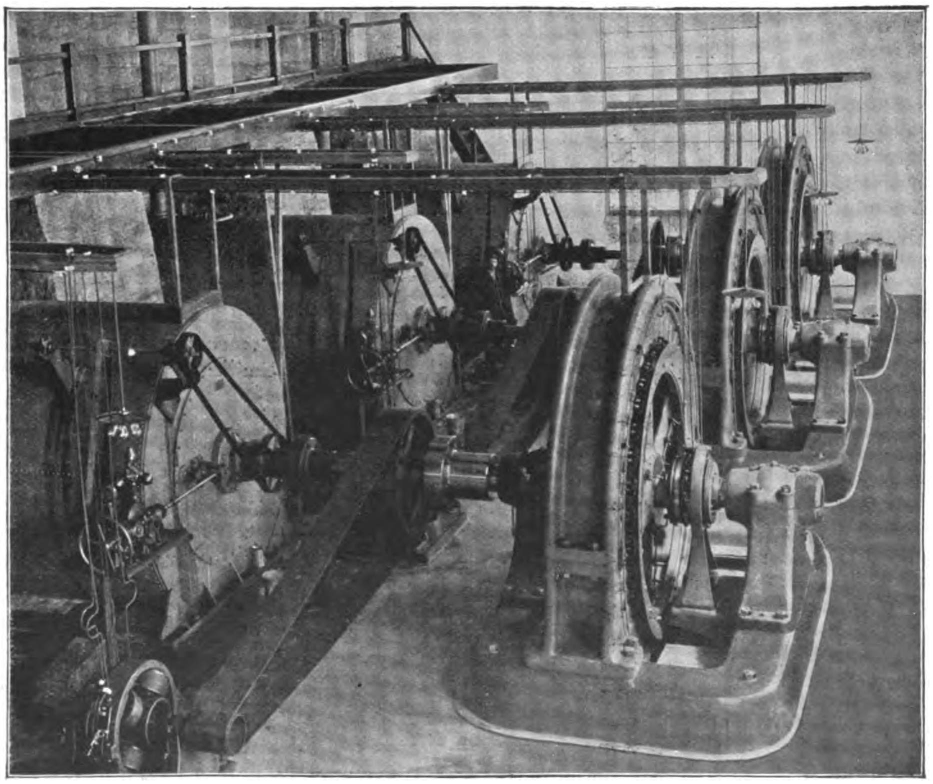


FIG. 1.—PELZER POWER HOUSE.

The motor equipment of the above mill aggregates 2080 HP, divided in twenty-four motors. Four of these, of 75 HP apiece, are in the picker room shown in Fig. 3. These are directly connected to the shafting and run at 600 r. p. m. Fifteen motors of 110 HP each drive the looms, carding and spinning machines, and the remaining motors are used for pumping, driving spoolers and blowers.

All of the above motors are non-synchronous, and are of the inverted type. They are suspended from the ceilings of the rooms in which they are employed. They have neither brushes, collector rings nor commutators, and consequently there is no sparking. The principal advantage presented by these motors is that they necessitate no attention whatsoever beyond that given to the bearings, and so long as these are kept properly lubricated, the motor will satisfactorily perform its duty. They are self oiling and are provided with oil glasses, by which the attendant can readily determine the amount of oil in the oil chamber.

By securing these motors to the ceiling a great saving in floor space is saved, and they are there beyond interference from curiosity, carelessness or accident.

To drive the machinery, each motor is, as far as possible, connected by four belts, two overhanging pulleys being keyed to each end of the motor shaft. From each end the two belts lead in opposite directions to the shafting driven by the motor. This method of driving reduces to a minimum the amount of friction, while equalizing the strain upon the bearings and shaft. In cases where two belts only are driven by a single motor the pulleys are placed on one end of the motor shaft only, and the belts are led in opposite directions to the machinery shafting.

PERSONAL.

Mr. Eugene E. Bogart has succeeded to the business of the late A. L. Bogart, 22 Union Square, N. Y. Mr. A. L. Bogart, Jr., will remain in technical charge, and the long established, enviable reputation of the house in the electrical gas lighting industry will continue to be maintained.

Mr. J. Miyaki, M. E., a graduate of the engineering course of the Tokyo Daigaku, is on a semi-official visit to the United States to make a study of its principal electrical plants and manufactures. As a graduate of a university that scarcely ranks second to any in the world, Mr. Miyaki is well equipped, technically, to obtain the full benefit of his professional tour.

Mr. Patrick B. Delany, of South Orange, N. J., has been awarded, by the Franklin Institute, the Elliott Cresson medal for his system of mechanical telegraphy. Mr. Delaney, who is a past vice-president of the American Institute of Electrical Engineers, is firmly convinced that the day is near when the telegraph will largely replace the mails for business correspondence.

Mr. H. M. Littell has been elected vice-president of the Metropolitan Street Railway, and, in addition, will act as general manager of the company, which position he previously held with the Atlantic Avenue Railway Company, of Brooklyn. Mr. Littell, who is one of the best known street railway men of the United States, was elected president of the American Street Railway Association at the Montreal Convention last year.

Mr. Max Osterberg, E. E., M. E., has taken an office at 27 Thames Street, New York, and will practice as a consulting engineer and electrical expert, making a specialty of gas-engine electrical installations. Mr. Osterberg when at Columbia University was fortunate enough to carry off one of the much prized Columbia fellowships. At the recent National Electrical Exhibition he had charge of the practical electrical laboratory, and during the past half-year has done some notable experimental work in Röntgen ray phenomena.

Mr. Elias E. Ries, formerly of Baltimore, Md., has opened an office as consulting engineer and electrical expert, at No. 1031 Temple Court. Mr. Ries is well and favorably known to the electrical profession as a scientific investigator and technical expert of no mean ability, and there is scarcely a line of applied electricity in which he has not done valuable original work. Mr. Ries is an active member of the American Institute of Electrical Engineers and other learned societies, has been a frequent contributor to the electrical and engineering press, is himself an inventor of marked capability, and has extended practical experience which well qualifies him for his new field and which fully merits the success that we have no doubt he will reap.

Mr. Ernest H. Heinrichs has added a new proof of his versitility. Known throughout Western Pennsylvania and Eastern Ohio as a brilliant journalist, and in industrial circles as the efficient press representative of the Westinghouse interests, he has more recently made his bow to the general public as a novelist. In "Helene, a Novel," Mr. Heinrichs presents a cleverly written story whose interest is enhanced by the true picture which it gives of German life and social customs. Like the modern French novel, the tale has an underlying *motif*. The German system of caste is the object of attack, and by shifting the scene of the latter part of the story to the United States, the author brings into greater contract the absurdities of German social prejudices.

OBITUARY.

Dr. Wm. Shrader, who died at Columbus, Mo., last month, is a severe loss to the electrical and scientific world, in which he was such an able and conscientious worker. The cause of his death is attributed to his close application to some investigations he was making at the time in regard to Röntgen ray phenomena. Physically of frail constitution, his devotion to duty frequently led to overtaxing his strength. Dr. Shrader was thirty years old, a native of Indiana, and unmarried. He was a graduate of the Rose Polytechnic Institute of Terre Haute, Ind., and also spent five years in the study of physics and electricity under such teachers as Helmholtz and Kohlrausch. The degree of Doctor of Philosophy was conferred upon him by the University of Strassburg. In 1891 he was appointed Assistant Professor of Physics in the University of the State of Missouri, and two years after was elected Professor of Electrical Engineering, which position he held at the time of his death. Dr. Shrader will be remembered as one of the thirty judges of the electrical exhibit at the World's Fair, where he won many friends.

NEW BOOKS.

THE PRINCIPLES OF THE TRANSFORMER. By Frederick Bedell, Ph. D. New York: The Macmillan Company. 416 pages, 250 pages. Price, $3.25.

This work is more especially adapted for use in college teaching than for industrial purposes, though its very clear exposition of the physical and mathematical theory of the transformer will be appreciated by the designer and the electrical reader acquainted with the calculus and the intricacies of graphical constructions. Such actions of the transformer as admit of mathematical treatment are here thoroughly considered, both analytically and graphically, and a final chapter deals with some of the effects of hysteresis and eddy currents.

THE ALTERNATE CURRENT TRANSFORMER IN THEORY AND PRACTICE. By J. A. Fleming. Vol. I. The Induction of Electric Currents. New Edition. London: The Electrician Printing & Publishing Company. 606 pages, 213 illustrations. Price, $5.00.

The new edition of this standard work, the best treatise in any language on the transformer, has been thoroughly revised, the greater part of the chapters having been rewritten. The size is considerably larger than that of the first edition, 127 pages having been added; most of the illustrations have been re-engraved and some new ones added. While the reading of the entire book requires a knowledge of the simple calculus, the pages containing mathematical demonstrations are comparatively few in number, and the earnest student without mathematical knowledge will be able to follow the text through most of the pages.

A PRACTICAL TREATISE ON THE OTTO CYCLE GAS ENGINE. By William Norris. New York: Longmans Green & Company. 260 pages, 207 illustrations.

This work is intended to furnish engineers, draughtsmen and students with practical data, based on results obtained by the leading makers of the Otto type of gas engines. The various commercial forms of this type are described and illustrated, and their various parts, such as gas valves and cocks, starters, ignition tubes, reciprocating parts, flywheels, etc., are treated in very full detail. The latter portion of the book is devoted to tests and testing, full descriptions of the necessary devices and fittings being given. The final chapter is on the use of the gas engine for electric lighting. The work is a very satisfactory one and will be found of value by those interested in the gas engine.

TRADE PUBLICATIONS.

Blow Torches. The White Manufacturing Company, 40 State Street, Chicago, in a sixteen-page catalogue illustrates a number of types of gasoline blow torches specially adapted for electrical work. A combination hot blast gasoline furnace for electricians and conduit workers is also illustrated, and presents an efficient appearance.

Oil Filters. The Phoenix Automatic Filter Company, Racine, Wis., has just issued an interesting treatise on "Oil Filters" that it will be glad to send to any reader of this Journal who asks for it. The filter which the company makes is especially adapted to filtering dynamo oils, and consequently is largely in use by electric lighting and railway plants all over the country.

Power Pumps. In a well illustrated thirty-two-page catalogue, Henion & Hubbell, 61 Jefferson Street, Chicago, Ill., describe a large line of power pumps, among which are a number designed to be actuated by electric power. Among these are electric house pumps, electric elevator pumps, electric water tank pumps and electric fire pumps. Among the devices illustrated is a hydraulic switch motor and pump, motor rheostat.

Isolated Electric Lighting Plants. The C. & C. Electric Company, 134 Liberty Street, New York, in a recent pamphlet on "Isolated Electric Lighting Plants," gives much valuable technical information on that subject. In addition, the pamphlet contains a collection of data and formulas which will be much appreciated by engineers and electricians, who will find it to their interest to obtain a copy of the publication by application to the company.

The General Electric Company has in press a little booklet on its "Long Burning Arc Lamps," handsomely illustrated. The subject is treated from the standpoint of the convenience and economy of the station manager and the customer, by the use of these 100 and 150-hour lamps. This booklet will be ready for distribution in a few days, and our readers can receive a copy, on application to any of the sales offices of the company, or directly to the supply department at the Schenectady office.

Electrical Supplies. A new edition of the catalogue of household, telephone and telegraph supplies of the Manhattan Electrical Supply Company, 32 Cortlandt Street, New York, contains no less than 224 pages, and more than 500 illustrations. The same company has also issued a sixty-four-page descriptive pamphlet of bicycle, electrical and photographic supplies. With these two publications at hand, the electrician will be equipped to meet any possible emergency that may arise with respect to prices and specification of articles in the several departments comprised within their scope.

Indicator Card Scales. Hine & Robertson Company, 168 Cortlandt Street, New York, have had printed on strong card-board for the convenience of those using indicators, scales for 12, 16, 30, 40, 50 and 60-lb. indicator springs, and a table of areas of circles, from the diameter of the smallest piston rod to 56-in. cylinders. The scales, if purchased separately in boxwood, would cost $2, and in their present form are more legible and convenient for use than boxwood scales. Any of our readers may obtain one of these useful cards, free of charge, upon application to the Hine & Robertson Company.

Electrical House Goods. Huebel & Manger, 289-293 Graham Street, Brooklyn, have issued a new catalogue of bells, push buttons and electrical and brass goods, which will be forwarded to any of our readers upon application. Full lines of iron frame and box bells, wood box bells, push buttons plain, ornamental and special, wood and rubber switches, window and door springs, binding posts, etc., are shown in well executed cuts. In a note the manufacturers state that in their bells they only use pure platinum-riveted contacts, lock-nut and immovable binding and contact posts, and a patented method of adjustment, thus insuring the highest efficiency of operation.

Westinghouse Engines. In a new and handsomely executed catalogue, the Westinghouse Machine Company, Pittsburgh, Pa., gives a number of fine half-tone illustrations of the various types of the Westinghouse automatic engine, and views of some of the more important electrical generating plants with which this engine is used. Among the latter are the power plants of the Philadelphia Traction Company and Brooklyn City Railway Company; the electric lighting plants of the Brush Electric Company, Baltimore, and the United Electric Light & Power Company, New York; the electrolytic plant of the Bridgeport (Conn.) Copper Company; the engine room of the Philadelphia station of the Pennsylvania Railroad; the lighting plant of the Capitol at Washington, D. C., etc. One of several the respects in which the pamphlet will be useful to the electrical engineer and others is in showing modern arrangements of generating plants.

Electric Heating. The American Electric Heating Corporation, Sears Building, Boston, Mass., has issued two new catalogues of electric heaters, one dealing with car heaters, and the other with apparatus for domestic use. Of car heaters a half dozen types are shown, and special forms of switches and cutouts for this service are described. For domestic use there is manufactured a full line of cooking devices, laundry irons, tailors' goose irons, portable house warmers, glue pots, bicycle tire vulcanizers, curling irons, etc. To illustrate the advantages of electric heating, the smoothing iron may be taken as an instance. With the old method of heating irons, the mass of metal is raised to a high temperature, which is quickly lowered when the iron is applied to the work. For the first very few minutes the iron works fairly well, then as it begins to cool it requires more and more rubbing to accomplish the work which was done in a very brief time when the iron was "just right." An electric iron, being a generator, is "just right" all the time, and the work progresses with such rapidity that in cases of continuous work there is an increased output per operator varying from thirty-three to fifty per cent. This alone would more than pay the whole of the cost for current supplied in industrial establishments. In addition to this, the temperature in the room in the summer months is never increased appreciably, while the great increase in temperature due to the use of stoves or gas heating appliances is frequently such as to decrease the output of the operator materially. No time is lost in cleaning the iron, no goods are injured by smoke or soot, etc., etc.

BUSINESS NOTES.

Field & Hinchman, consulting engineers, have removed their offices to 1203–1204 Majestic Building, Chicago.

The Rankin & Fritsch Foundry & Machine Company, St. Louis, Mo.—In the notice in our August issue of the two 1500-HP engines sold by this company to the Milwaukee plant of the Illinois Steel Company, the weight was erroneously given at 240,000 lbs. each; this figure should have been 340,000 lbs. for each engine.

H. B. Coho & Company, 203 Broadway, New York, report business in general to be first rate. Among the large orders received lately were several for 100-KW and 50-KW Eddy generators for the St. Paul Building, New York, and a complete electric plant for the Scranton Poor District. Their business in Eddy motors of all sizes is also very good.

The Baechtold & Parker Electric Company, 79 Washington Street, Brooklyn, has found it necessary to take more factory space in order to handle its rapidly increasing business. In addition to general repair work, the company makes a specialty of repairs to Wood arc dynamos and arc lamps, for which work its shops are especially well equipped.

W. H. McKinlock, president of the Metropolitan Electric Company, Chicago, reports a decided improvement in business, especially in the telephone line. The Gordon cell, for which this company is the Western agent, is rapidly coming into favor with telephone, telegraph and railroad companies. The No. 1 Gordon cell is specially adapted for track circuit work, and the No. 2 for telephone service.

Dixon's Graphitoleo. In a recent circular the Joseph Dixon Crucible Company, of Jersey City, describes this preparation, which is a preparation of a very finely pulverized and very choice graphite and a pure petroleum warranted not to gum or become rancid. An article thus combining a perfect lubricant and rust preventive, put up in convenient form will be appreciated by the electrician and engineer.

The American Stoker Company, Dayton, O., has recently furnished the following stoker equipments:—Pennsylvania Railroad Company shops, Columbus, O. (second order); Davis & Egan Machine Tool Company, Cincinnati, O.; Toledo Brewing & Malting Company, Toledo, O.; Michigan Carbon Works, Detroit, Mich. (second order); John C. Roth Packing Company, Cincinnati, O.; Cleveland City Water Works, Cleveland, O.

Whiteside & Foster, Western representatives of the Fischer Foundry & Machine Company, have closed a contract with the Western Electric Company for two 225-HP, four-valve, center-crank Fischer engines, to be direct connected to two of the Western Electric Company's well known type of multipolar generators. This plant will be used for the purpose of illuminating the extensive shops of the Western Electric Company.

J. Holt Gates has been appointed Western sales agent of the Walker Company, of Cleveland, O. Mr. Gates is also Western sales agent of the C. & C. Electric Company, New York, and in his salesrooms at 311 Dearborn Street, under Manhattan Building, he carries a full line of dynamos and motors, enabling him to make prompt shipments. With the Walker and C. & C. companies' agencies, almost any requirement can be filled immediately.

Mr. H. M. Montgomery for some time associated with the Goubert Manufacturing Company, of New York City, and previous to that for several years associated with the Babcock & Wilcox Company, has gone with Thayer & Company, Inc., of Boston, New York and Philadelphia, to be located in its New York office, in the selling department of Cahall and Babcock & Wilcox boilers, manufactured by the Aultman & Taylor Machinery Company, of Mansfield, O.

Travel. Those of our readers to whom the transcontinental trip is but a vague abstraction, will find a half hour's pleasure in making the voyage in imagination with the aid of two handsome pamphlets which may be obtained by application to E. Hawley, assistant general traffic manager of the Southern Pacific Railroad, 343 Broadway, New York. Both of the pamphlets "Sunset Limited" and "Hotel Del Monte," are handsome specimens of the printer's and engraver's art.

Mr. Chas. Holmes, the well known purchasing agent of the Chicago Edison Company, returned recently from a two months' pleasure trip in England, Ireland and Scotland. The trip was to enjoy a much needed vacation and was spent entirely in pleasure. While he did not devote any particular time or attention to electrical matters, Mr. Holmes says that his observation in regard to business in general was, that the times are much more prosperous in Great Britain than in this country.

The Hoppes Manufacturing Company, of Springfield, O., manufacturer of the well known "Hoppes" purifiers and heaters has been fairly busy for the past sixty days, having sold over 9000 HP of its product. Among some of its recent sales we note the following:—Purifiers of the following HP: 850 (two), 750, 400, 300 (two), 250, 150 (two), 100 and 50 (two). Feedwater heaters of the following HP: 1200, 850, 600, 500, 400, 200 (two), 150 (four), 100 (two) and 75. One of the purifiers was for export, and amomg the states represented we find the extremes of Massachusetts and Texas.

The Electric Appliance Company, Chicago, has been particularly successful during the past month in closing some large deals for "O. K." weatherproof wire. Several orders for good-sized complete new plants have been booked, together with some large orders for extensions for already existing plants. The company also reports that its success with Armorite iron-armored interior conduit is away ahead of its expectations, and its sales have already been very large. The construction trade recommends Armorite very highly on account of the ease with which the wire can be drawn into the tube, and also for its flexibility, which allows its use without elbows or couplings, saving time and expense in installing.

The Armorite Interior Conduit Company, Detroit, is meeting with excellent success in the introduction of its new interior conduit. The president of the company, Mr. J. F. Cummings, who is also the inventor of the system, states that architects are generally specifying it, and altogether the sales of the conduit have been most gratifying, considering the short time that it has been on the market. The special feature of this conduit is that the interior insulation is very substantial and conforms to the iron tube in which it is placed in whatever way it is bent. A new catalogue and price list has just been issued by the company, which the company will send, free of charge, to any reader who mentions the AMERICAN ELECTRICIAN.

The Colliery Engineer Company, proprietors of the *Colliery Engineer and Metal Miner*, of *Home Study* and the "International Correspondence Schools," have suffered from a fire, which occurred in the Coal Exchange Building, Scranton, Pa., on Sunday morning, Aug. 30, 1896. Fortunately, the printing plant of the company was in another building, and having reserves of all instruction and question papers, drawing plates and other supplies and stationery used in the schools in still another building, its business will not be seriously interfered with. The *Colliery Engineer and Metal Miner* and *Home Study* will be out within a few days of the usual time, and the instruction in the several schools is being carried on as usual. New quarters have been secured on the three upper floors of the new Mears Building, corner of Washington Avenue and Spruce Street, Scranton.

The Proof of the Pudding. It is gratifying to manufacturers to receive a duplication of orders for their goods from people who, having tried them, are thoroughly familiar with their merits. In this particular, the J. H. McEwen Manufacturing Company, Havemeyer, Building, New York, is particularly fortunate, and the company may well be proud of the numerous orders already received from former patrons, the latest one coming from the well known firm, Messrs. A. M. Rothschild & Company, of New York and Chicago. Messrs. Rothschild & Company have had in operation for the past eighteen months two 100-KW Thomson-Ryan generators direct connected to 15 in. × 16 in. McEwen automatic engines. In reply to an inquiry, they sent the following letter, dated June 26, 1895: "In reply to yours of the 24th inst. would state that the plant of the McEwen people is entirely satisfactory, and cannot recommend same any too highly." They have just placed an order for the third machine of the same size as the first two and thus verifying their opinion formed over a year ago.

CALIFORNIA.

If you are going there

by all means inquire about the Burlington Route Personally Conducted Excursions to San Francisco and Los Angeles, which leave Chicago every Wednesday with a Pullman Palace Tourist Car through to destination. The Route is via Denver, the Denver & Rio Grande Ry. (Scenic Line) and Salt Lake City. The Cars are fitted with carpets, upholstered seats, mattresses, pillows, blankets, bed linen, berth curtains, toilet rooms, heat and light, and, in fact, all the conveniences of a standard Pullman Palace car; they lack only some of the expensive finish of the Pullmans run on the limited express trains, while the cost per berth is only about one-third (⅓) of the price.

Write for full particulars to T. A. GRADY, Excursion Manager, C., B. & Q. R. R, 211 Clark Street, Chicago, Ill.

Harvest Excursions.

In order to give everyone an opportunity to see the grand crops in the Western states and enable the intending settlers to secure a home, the Chicago, Milwaukee & St. Paul Railway has arranged to run a series of harvest excursions to South and North Dakota, and to other states in the West, Northwest and Southwest on the following dates: July 21, August 4 and 8, September 1, 15 and 29 and October 6 and and 20, at the low rate of $2 more than ONE FARE for the round trip. Tickets will be good for return on any Tuesday or Friday within twenty-one days from date of sale. For rates, time of trains and further details apply to any coupon ticket agent in the East or South, or address F. A. Miller, Assistant General Passenger agent, Chicago, Ill.

A Handsome Book for a Two Cent Stamp. New Publication by the D. & C. Line.

To those who contemplate taking a summer outing, we will mail for 2c. postage our illustrated pamphlet, which contains a large number of fine engravings of every summer resort between Cleveland, Toledo, Detroit and Picturesque Mackinac. It has many artistic half-tones of points of interest of the Upper Lake region. Information regarding both short and extended tours, costs of transportation and hotel fare, etc.

Address A. A. SCHANTZ, G. P. A.
Detroit, Mich.

Tours in the Rocky Mountians.

The "Scenic Line of the World," the Denver & Rio Grande Railroad, offers to tourists in Colorado, Utah and New Mexico the choicest resorts, and to the transcontinental traveler the grandest scenery. The direct line to Cripple Creek, the greatest gold camp on earth. Double daily train service with through Pullman sleepers and tourists' cars between Denver and San Francisco and Los Angeles.

Write S. K. Hooper, G. P. & T. A., Denver, Colorado, for illustrated descriptive pamphlets.

Did You Ever See an Indian?

Expect not, so send a two cent stamp to the General Passenger Agent Colorado Midland Railroad, Denver, and he will send you a fine colored picture of one.

Spend Your Vacation in the Mountains.

But first write the General Passenger Agent of the Colorado Midland Railroad, Denver, for maps, views, and descriptive matter, so as to know where to go.

American Electrician.

Vol. VIII. New York, October, 1896. No. 6.

THE EVOLUTION OF THE STREET RAILWAY MOTOR.

BY CHARLES T. CHILD.

ALTHOUGH the history of the street railway motor covers so short a period of time, it is difficult to assign the credit of its first conception. As early as 1825, Faraday had produced his revolving disk, which was probably the first electric motor. In Europe, it was thirteen years later before Jacobi made the historical motor which seems to have been the first attempt on that side of the Atlantic to obtain an appreciable working power from the electric current.

The honor of being the first to attempt electric locomotion probably belongs to an American, Thomas Davenport, of Brandon, Vt. In 1835 he exibited a little circular track, upon which a car was operated by current from primary batteries carried in the car. His motor was of the crudest possible type, a revolving electromagnet which successively attracted fixed bars of iron.

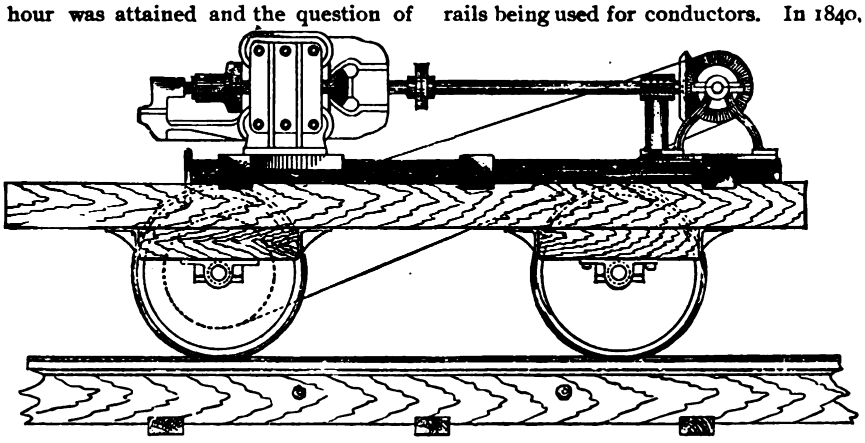


FIG. 1.—THE EDISON-FIELD MOTOR—CHICAGO, 1883.

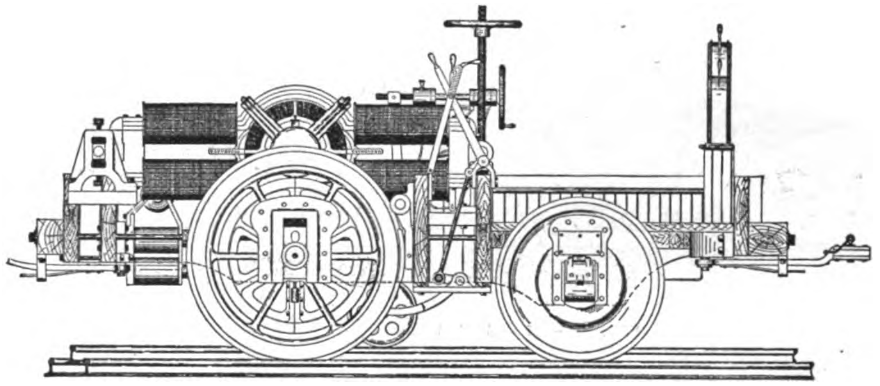


FIG. 2.—THE DAFT MOTOR—BALTIMORE, 1885.

The first serious attempt to propel a railway passenger car was made by Robert Davidson, of Aberbeen, Scotland, in 1838. In that year he built an electric locomotive of standard railway gauge, carrying an enormous battery of zinc and iron plates, with a motor consisting of a revolving drum faced with iron bars, and having a commutator which controlled the action of large fixed electromagnets. This machine made several successful trips on Scotch railways before it met its fate—malicious destruction by railway employes.

The next attempt was made in this country by Prof. C. G. Page, of the Smithsonian Institution. In 1850, he built a motor of ten horse-power upon the lines of a steam engine, a solenoid-attracting arrangement taking the place of the cylinder. His second motor, of sixteen horse-power, used a U-shaped core attracted into two solenoids which were made with a graduated winding, giving a longer and more uniform stroke. With this motor and one hundred cells of Grove battery mounted upon a car, he made a round trip from Washington to Bladensburg, on the Baltimore & Ohio Railroad, in April, 1851. A speed of nineteen miles per hour was attained and the question of the possibility of electric traction was considered to be forever settled. The results plainly showed that with the only means of generating electric currents of sufficient power then known, the primary battery, the cost was prohibitive. For twenty-seven years no experimenter entered the field of electric traction and the labors of the earlier inventors were regarded as instructive lessons which pointed out the fallacy of such an undertaking.

In 1864, Paccinotti made his ring electric machine, the parent of the modern dynamo and motor. Three years later Siemens found that his dynamo was reversible and would run as a motor. Shortly before this, Wheatstone in England, and Siemens in Germany, had independently invented the method of self-excitation for dynamos, and it only needed the labors of Gramme, in 1873, to establish the commercial practicability of the dynamo machine and clear the way for the pioneers of the electric railway.

Meanwhile, several ideas had been developed in cognate branches of invention which were to be of use in the future development of electric traction. In 1851, Prof. M. G. Farmer had built a model electric locomotive, not materially different from Page's, but with its source of current stationary, the rails being used for conductors. In 1840, an English patent for telegraphy to moving trains had foreshadowed the trolley.

It was not until 1878, that serious experiments were again undertaken. George F. Green, of Kalamazoo, Mich., built in that year an experimental railway, using the rails for leading the current and proposing the use of the overhead wire. Poverty and the lack of encouragement prevented his success, although his inventions contained the germs of many subsequent developments.

The first electric railway of the modern type was put in operation by Siemens and Halske, at the Berlin Industrial Exposition, of 1879. The motor was a Siemens dynamo with a double gear reduction. The third rail method of conduction was used, and here, for the first time, a dynamo machine was used in place of batteries as the source of current.

For four years the rivalry of two inventors, T. A. Edison and S. D. Field, prevented the accomplishment of any practical work in this country. Neither of them, however,

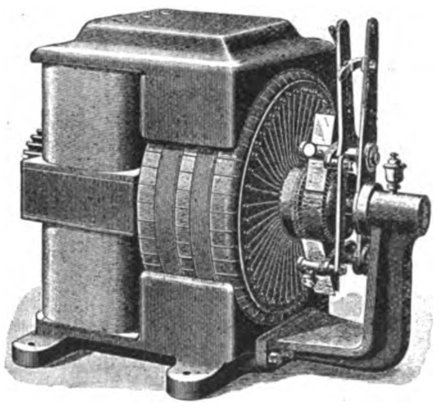


FIG. 3.—THE VAN DEPOELE MOTOR—MONTGOMERY, 1886.

had applied for patents until some time after the Berlin Exposition success of Siemens and Halske. In Germany, these engineers had built, in 1881, a road between Lichterfelde and the Central Cadetten Anstalt near Berlin, which was the first commercial electric railway, and had equipped the Charlottenburg and Spandau horse car line. On this latter the overhead wire was used for the first time.

The summer of 1883 saw the beginnings in this country of serious work in the railway field. The conflicting interests of Edison and Field having been consolidated, they exhibited, in June of that year, at Chicago, an electric locomotive with belt connections to the axle. Their motor was practically a Siemens dynamo. This machine was successfully operated during the summer upon a short track, the third rail system being used. In the autumn of the same year, Leo Daft began his experiments on the Mount McGregor road at Saratoga. His motor-car was of twelve horse power and was used to haul a ten-ton passenger car over 1¼ miles of road. The trial trip was considered a pronounced success, sixty-eight passengers being carried at a speed of eight miles per hour, despite heavy grades.

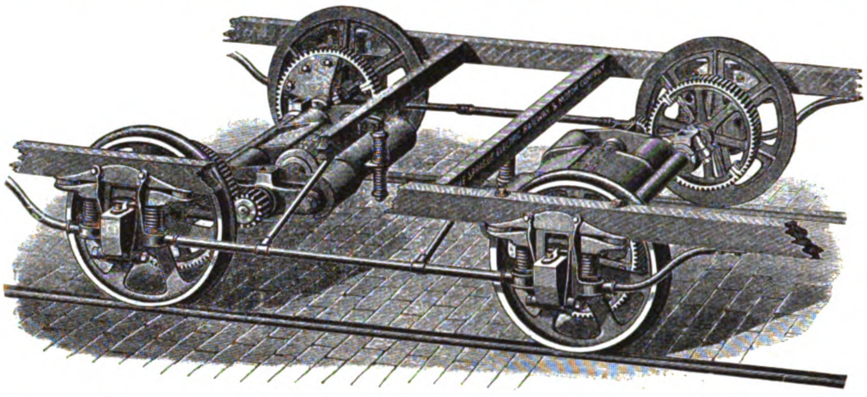


FIG. 4.—SPRAGUE MOTOR—RICHMOND, 1887.

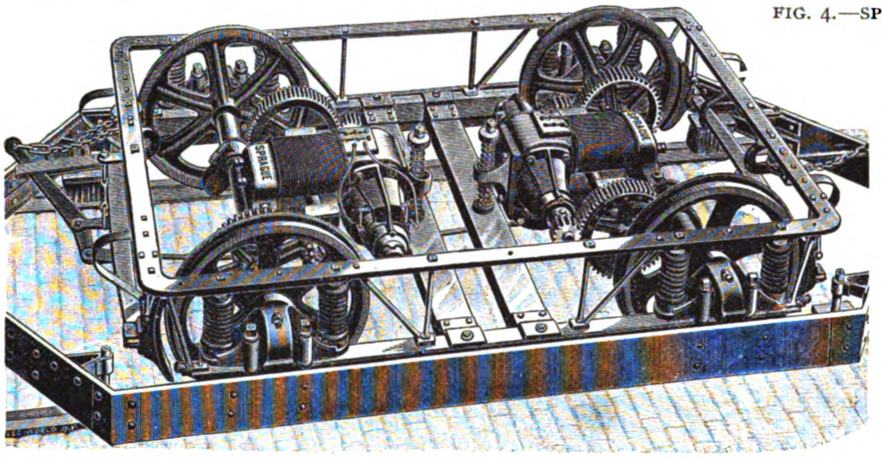


FIG. 5.—SPRAGUE MOTOR—RICHMOND, 1888.

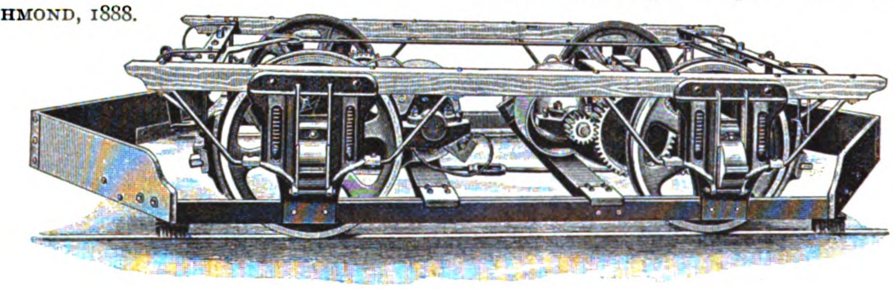


FIG. 6.—THOMSON-HOUSTON MOTOR—1888.

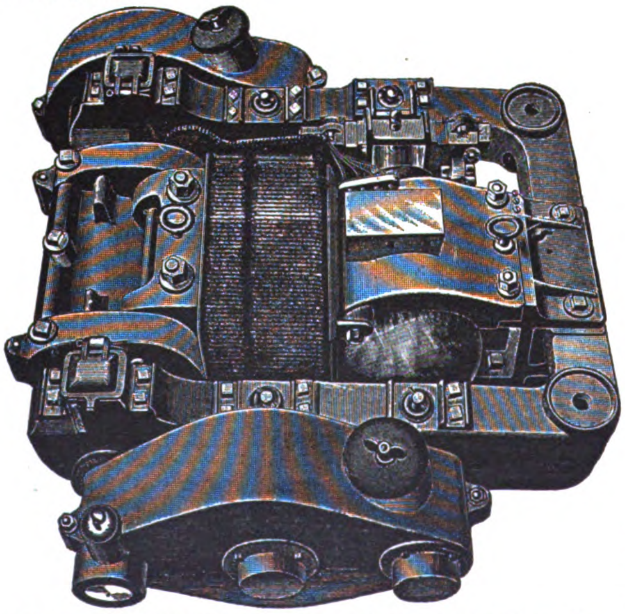


FIG. 7.—WESTINGHOUSE DOUBLE REDUCTION MOTOR—1890.

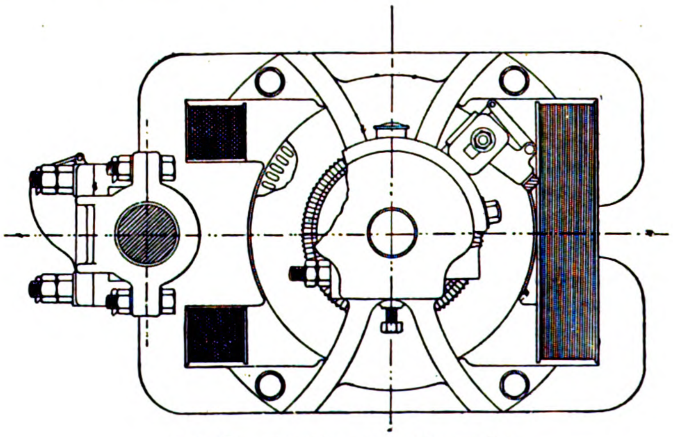


FIG. 8.—WENSTROM MOTOR—1890.

This motor was noteworthy in many respects. The field winding was in sections, the arrangement of which was controlled by a " Multiseries " switch. Iron wire was used on the fields, partly to gain resistance and partly in the belief that it would help the magnetic conditions of the motor. The potential was maintained practically constant at 100 volts upon a third rail insulated on tarred wooden blocks.

The first commercial installation in America was on the long pier at Coney Island in 1884, a Daft motor of the Mount McGregor type being used. In the same year the first actual electric street railway, in direct competition to horses was opened at Cleveland, O., by E. M. Bentley and W. H. Knight. Strange to say, this was a conduit road. The motor was hung from the under side of the car body and power was transmitted to the car axles through wire rope belts. The conduit was a shallow wooden box.

The first practical overhead line in America was opened in the autumn of 1884 at Kansas City, Mo., the inventor being John C. Henry. In this installation a number of radical departures were made, some of them being highly ingenious. A 5-HP Van Depoele motor was used and was allowed to run continuously, the car axle being thrown in and out of gear at will by a friction clutch. A system of spur gears allowed five changes of speed. The motor speed was controlled by a ball governor, which threw resistance into the main circuit if the speed went too high. The motor, clutch and nest of gears, were hung in a square frame, one end of which was pivoted on the axle and the other supported by the platform. Henry used a two-wire overhead circuit, but seems also to have tried track return. His motor is notable as being the first one pivoted upon the car axle in the way now almost universally in use. In these experiments an arc light dynamo furnished the current, and the potential frequently rose to 1000 volts.

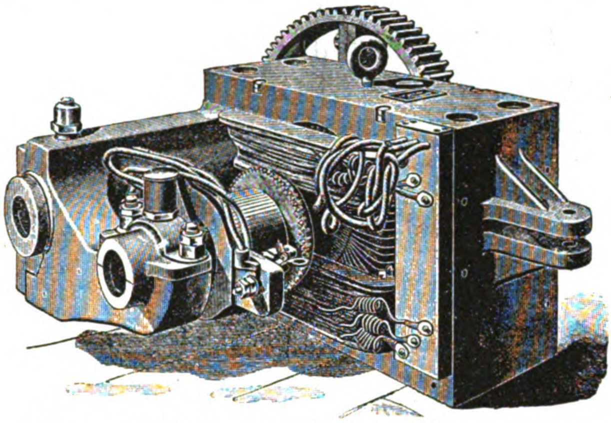


FIG. 9.—THOMSON-HOUSTON SINGLE REDUCTION GEAR MOTOR—1891.

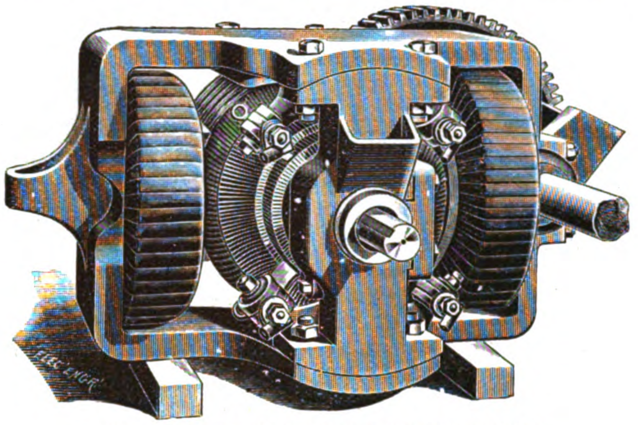


FIG. 10.—EDISON SINGLE REDUCTION GEAR MOTOR—e891.

In 1885, Daft constructed the most important road to that date, from Baltimore to Hampden. The locomotives were similar to that used at Mount McGregor, and hauled trains of one or two ordinary horse cars over a road having sharp curves and difficult grades. The motors were of 12 HP, having surface-wound Gramme ring armatures and fields built up of soft iron bars like the first Siemens dynamos. The motor was swung from both axles and geared to one of them by sprockets and chains. The front and rear wheels of the motor car were linked together like the drivers of a steam locomotive, by connecting rods. The control was by commutation of the field winding. A third rail was used, except at road crossings, where an iron gas-pipe held on bracketed poles served as conductor. On the roof of the locomotive was a mast arm, adapted to be raised by hand from the inside, and carrying a flat metal brush to make contact with the overhead conductor. This was probably the first use of the underrunning trolley. The potential was maintained constant at 100 volts, two shunt wound dynamos furnishing the current. The simultaneous operation of several cars on this line settled the contentions of those who maintained that motors could not be successfully worked in parallel.

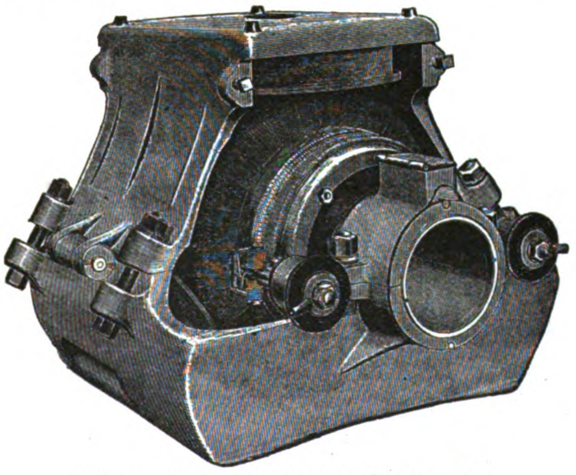


FIG. 11.—SHORT GEARLESS MOTOR—1891.

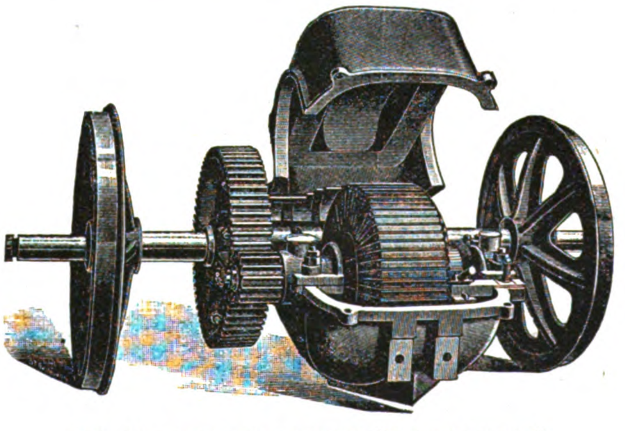


FIG. 12.—THOMSON-HOUSTON "WATERPROOF" MOTOR—1891.

The experiments of C. J. Van Depoele in the electric motor field began in 1874. In 1884 he operated a car at Toronto, Ont., at the Exposition of that year, and in 1885 he built a large locomotive for passenger service in the same city. This machine was similar in its general arrangements to Daft's, and was operated from an overhead circuit, the trolley running on the upper side of the wire. The motor was built for constant current, a 40-light arc machine being used as generator at the station. In 1886 Van Depoele constructed a similar line at Minneapolis.

Experiments made in 1885, and Daft's results at Baltimore, having shown that several cars could be operated in multiple from a constant potential circuit, Van Depoele constructed in 1886 a line at Montgomery, Ala. His motors were of 10 HP, weighed 700 lbs. each, and one was carried on each car. The armature was a Gramme ring, wound on the surface. The fields were of cast iron. For regulation an auxiliary coil, practically a resistance coil, was wound on the field. There were two pairs of tangential brushes set in opposite directions in a frame arranged to lift one and put the other in contact with the commutator when the car was reversed. A similar arrangement had previously been used in the Daft motors at Baltimore. The armature shaft was geared to a countershaft, from which the axle was driven by a sprocket and chain. The trolley, running on the top of the wire, trailed out behind the car at the end of a flexible cable.

During the year 1886 the most noteworthy developments were the experiments of F. J. Sprague on the elevated railroad in New York City. His experiments were without immediate valuable results, but the experience gained in them and his successful work in the stationary motor field fitted him to essay the difficult task of the equipment of the Richmond road in 1887, and doubtless contributed to the brilliant success he achieved in that installation.

The Richmond road was opened early in 1888, with 13 miles of track, 20 cars in use, and six 40-KW generators at the power house. It was immediately and completely successful, and the principles there employed by Mr. Sprague underlie practically all that has been done since in railway motor design. The radical and novel features of the Richmond motors were the underrunning trolley, movable in all directions, fixed brushes, flexible support of the motors pivoted on the car axle, the use of a separate motor on each axle, and series-parallel control. The motors were of 7½ HP each and geared with a single reduction to the car axle, although this, and the series-parallel control, were abandoned shortly in favor of simpler devices for control and a gearing of two reductions, permitting higher armature speed. The standard pressure of 500 volts was adopted here for the first time.

The first improvement of the Sprague motors was the adoption of a simple U-shaped frame, putting the armature further from the axle and making room for the

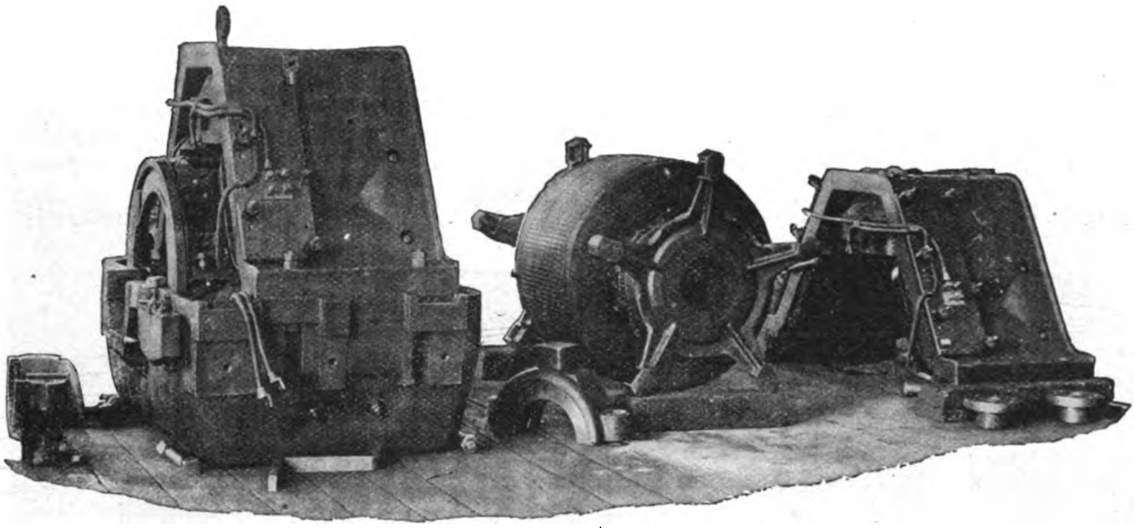


FIG. 13.—MOTOR OF 90-TON LOCOMOTIVE—BALTIMORE, 1895.

double reduction gear. The noise of spur gears running at high speeds, and their rapid wear, suggested the expedient of enclosing the gearing in tight boxes filled with oil. With added experience many minor modifications of the mechanical details were made.

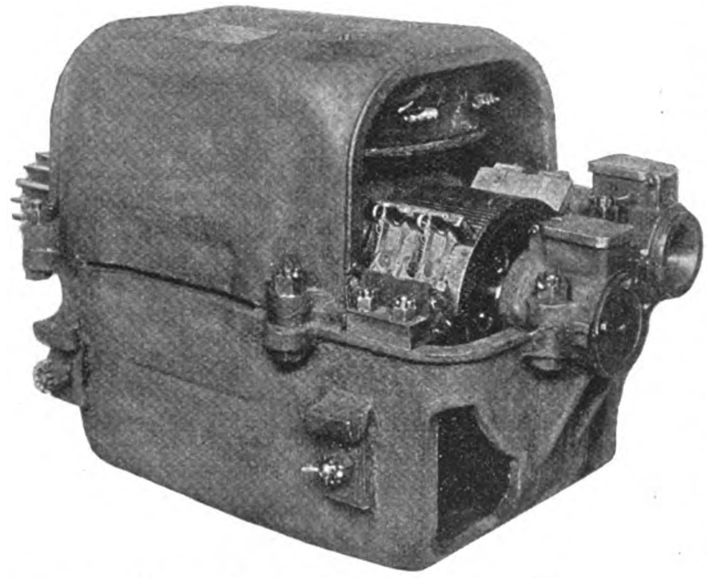


FIG. 14.—INTRAMURAL RAILWAY MOTOR—CHICAGO, 1893.

The motors of the 1887 type had Siemens cylinder armatures, wound on the surface, with a commutator at each end. In the 1888 type there was but one commutator, the general form of the armature being the same in other respects.

The Thomson-Houston Company having bought the Bentley-Knight and Van Depoele patents, entered the field in 1888 with a motor generally similar to the improved Sprague type, but different in the method of its control. A rheostat was used in the main circuit, and a portion of the field coils arranged to be cut out for the highest speeds. While many looked upon the rheostat as wasteful of current and a retrograde step, it served the important ends of keeping **the motors cool and reducing the shock of starting, the wear of the gears and the heavy currents that poured through the older types of motors before their armatures acquired speed.**

During the next few years a number of minor companies introduced new forms of motors, but no noteworthy advance in construction was made until the advent of the Wenstrom motor in 1890. This was a slow-speed, four-pole motor, having deeply imbedded armature winding, and proved to be the first practical, single reduction motor built. The following year saw the adoption of a similar type by the leading manufacturing companies.

In 1891 gearless motors, for direct connection to the car axle, were put upon the market by two companies and vigorously advertised, but eventually abandoned, their high cost as compared with the very satisfactory single reduction motors **practically ruling them out. Late in this year the dust and water-proof iron-clad motor made its appearance, and with slight modification has held its place until the present.**

Recent improvements have been in the direction of strength, better insulation, reduced weight and better methods of support. The old machines with heavy cast iron frames, inefficient magnetic circuits, surface-wound armatures running at high speeds, and windings and journals exposed to the dust and mud of the track, have evolved by slow steps into the powerful, compact and light motors of to-day, with their concealed working parts and almost indestructible construction. Few machines have been more often re-designed than the street railway motor and few are more successful. In the decade its weight and speed have been halved, while its torque has been doubled.

It is interesting to compare the old machines with those of to-day and to note what perfection of detail is embodied in the modern designs.

The Walker motor is an iron-clad, four-pole type, arranged for simgle reduction gear. Its field casting is of low steel, in two parts, each of which contains two of the four-pole pieces. The armature is of the drum type, deeply slotted, wound with flexible wire in the smallest size and with flat ribbons in the larger sizes, in both cases the coils being formed in a machine before application to the armature. After the windings are in position, the face of the armature is covered with a layer of insulating wrapping and then banded. The commutator is of drop-forged copper and is very heavily insulated with mica. All four of the poles are salient, the four identical coils being **wound on a former and heavily taped. The terminals of these coils are soldered to binding-posts which are taped into the coils,**

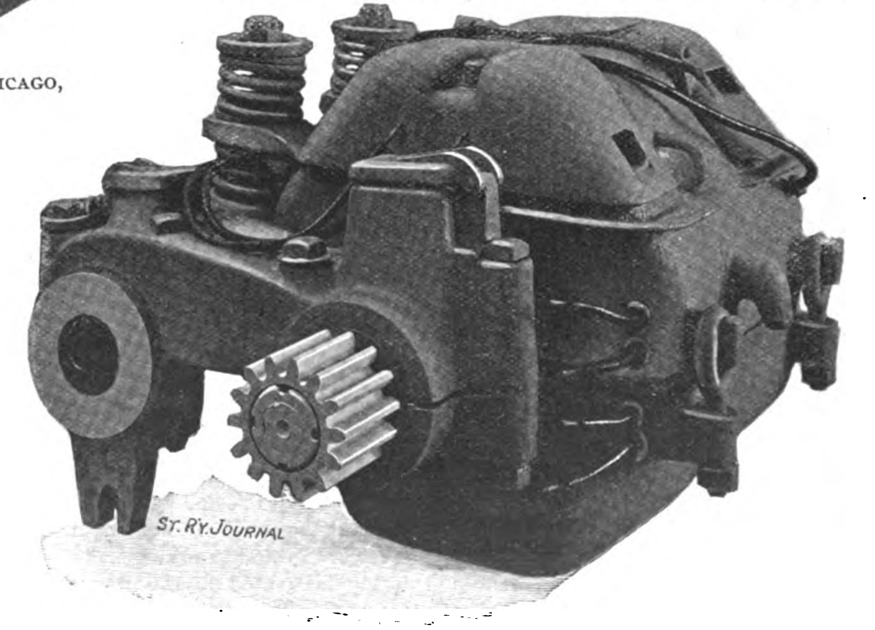
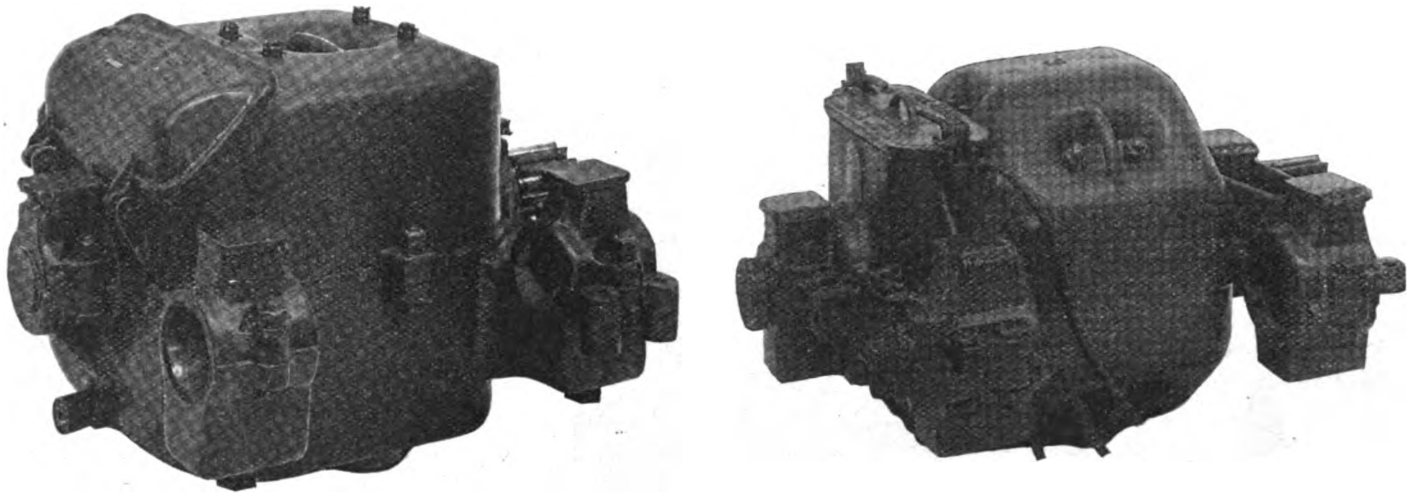


FIG. 15.—WALKER 25-HP MOTOR—1896.

leaving only their ends projecting to form a very solid and satisfactory connecting arrangement. The coils are secured to the polar projections of the field by brass clamps bolted on. The similarity of the four poles is claimed to produce a uniform balance of field which is highly desirable.

The bearings are entirely outside of the shell casting which forms the casing of the motor. The inner end of each bearing projects into a sort of pocket in the casting, in which runs a disk fitting loosely upon the shaft. Any grease or oil oozing through the inner end of the bearing is thrown centrifugally to the edge of this disk and flies off to impinge upon the wall of the pocket and flow down to a hole at its lowest point, where it falls out upon the ground.



FIGS. 16 AND 17.—GENERAL ELECTRIC—1896.

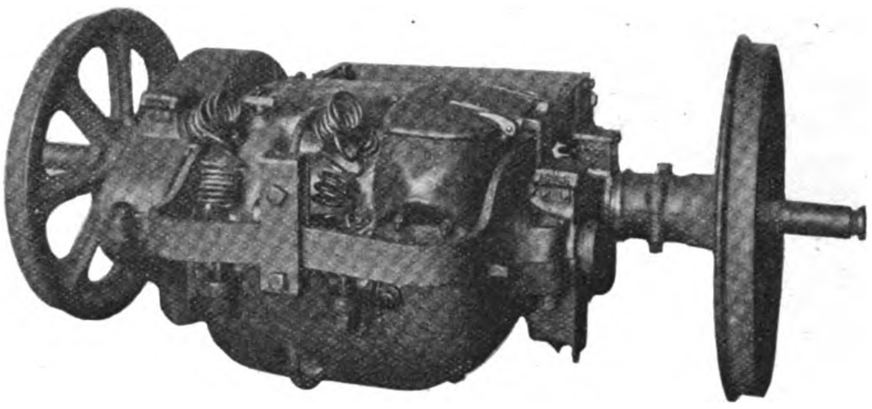


FIG. 18.—WESTINGHOUSE—1896.

The form of suspension characteristic of this motor is one of its chief features. The armature shaft, which is the axis of symmetry of the motor, passes through supports at the ends of a U-shaped frame, the base of which is clamped around the car axle upon which it bears, through suitable journals at the ends. Lugs are cast upon the motor case which project back towards the axle and engage with springs resting upon the base of the U-frame directly above the axle. On the front, or other side, of the motor case is a hook which engages with the ordinary spring-suspended cross-bar of the truck. By this arrangement the legs of the U-frame maintain the motor shaft and car axle at an invariable distance, keeping the gears in mesh, while the heavy motor is cushioned on springs in all directions. This obviates the otherwise severe "pounding" of the track when the weight of the motor is either wholly or in part rigidly borne by the axles.

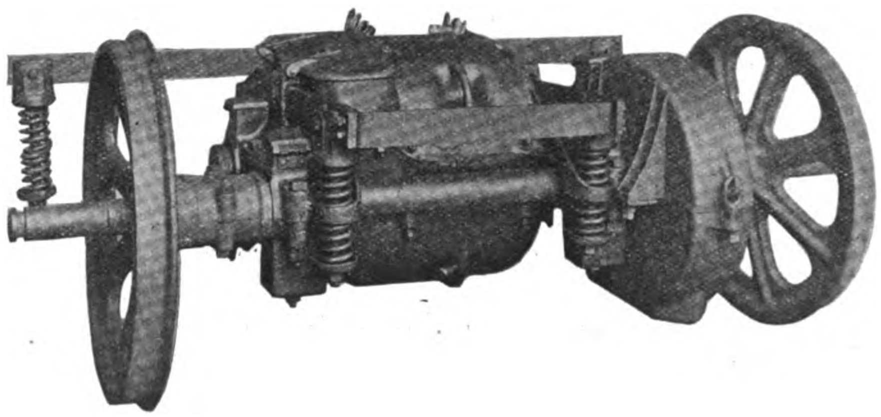


FIG. 19.—WESTINGHOUSE—1896.

The control of the Walker motor is not materially different from that of the standard forms.

The General Electric Company's most recent type is one designed to meet the conditions of both urban and suburban service, and intended primarily for use on cars that are to be operated from the heart of a city to its suburban districts. This motor is of the 4-pole single-reduction, iron clad type, all four poles being salient. The armature is of the usual drum form, deeply slotted, the winding being a modification of the Eickemeyer plan, by which all the coils are made exactly alike on a former and afterwards put in place on the armature. The frame of the motor consists of two bowl-shaped steel castings, hinged and bolted together, each of which carries two of the pole-pieces. The commutator is of very simple and substantial construction, with a large allowance for wear. The carbon brushes are held radially in simple brush-holders mounted upon an enameled wooden yoke. The bearings are very large and so constructed that either oil or grease may be used for lubrication. The ratio of gear reduction is 3.94 to 1, giving a very low armature speed.

The suspension of this motor is by the car-axle and a "yoke" which is attached to the forward part of the field casting and bent around backwards until its attachments to the truck frame are in line with the center of gravity of the motor. This is practically equivalent to a balanced suspension, and greatly relieves the hammer blow on the track caused by great weight of motor on the car axles. The control equipment is of the usual General Electric type, including resistance. The total weight of the motor is 1950 lbs.

The Westinghouse Electric & Manufacturing Company, has recently introduced a new type of 50-HP motor for use on interurban roads or in situations where high speed or great power is demanded. This motor has single-reduction gearing, four salient poles and the usual water-proof iron-clad field, cast in two parts and hinged together.

The upper and lower parts of the field form a completely enclosed casing in which are contained the armature, commutator, brushes, and field coils, which are thus entirely protected from dirt and moisture.

The armature is of the slotted drum type with machine wound coils and special arrangements for ventilation. The ends of the coils are not covered with caps, but are separated from each other by air spaces, which greatly facilitate the dissipation of heat. Each coil is enclosed in an insulating cell, and the design of the winding is such that the time required to remove and replace an injured coil is reduced to a minimum. In addition to the end ventilation, openings in the core parallel to the windings are so arranged that air is forced to circulate through them. The diameter of the armature is relatively small, reducing the peripheral speed and consequently the centrifugal strain upon the coils.

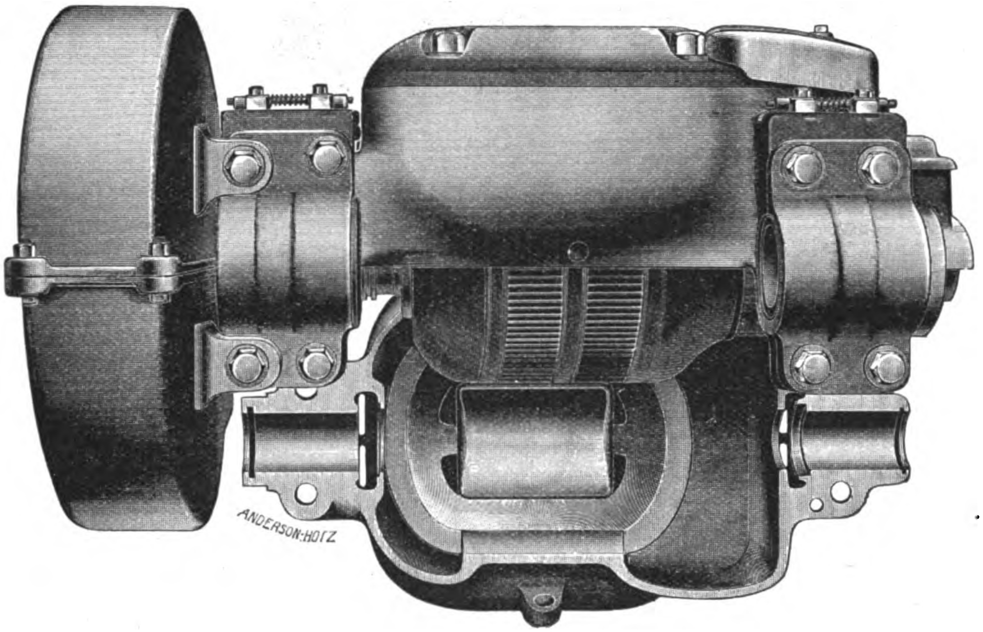


FIG. 20.—STEEL MOTOR COMPANY—1896.

The field coils are very solidly made and carefully insulated with mica. The commutator is large and contains an ample allowance for wear. The bearings are arranged so that the lubricant cannot get inside the motor case and reach the commutator or windings. The two bearings of the armature shaft are identical and interchangeable.

The "cradle" method of suspension is used with this motor, as is shown in the cuts, although the front method of suspension may be adopted in mounting it upon trucks to which the other is not well adapted.

The Steel Motor Company's type of enclosed single-reduction motor has four poles, of which two are salient and two are induced or consequent. The case is of low-carbon steel, made in two parts, each of which contains one of the salient pole pieces and half of each of the two consequent pole pieces. The armature is of the usual slotted drum type, with holes parallel to the shaft for ventilation. The coils are machine wound and laid in insulating troughs in the slots, after which a hard-wood strip is driven down on them and the armature banded. The heads are covered with canvas and brass shields, which prevent the coils from spreading at high speeds, but permit free circulation of air through the armature. The commutator is double keyed and of large size. The field coils are wound on brass spools for security against chafing. The bearings are phosphor-bronze, of generous size, and are provided with checks which keep oil out of the motor case.

The control is adapted to operate the motors either in series-multiple or multiple only. A divided resistance is used, and for certain steps of the control, a shunt coil in parallel with the fields, which increases the armature current while weakening the field, thereby accelerating the speed of the motor. In this motor, suspension is by the car axle and the forward end of the cast frame.

A comparison of these modern types shows the substantial agreement between different designs growing out of widely different original types. The latest developments of the street car motor by different makers are nearly identical, all of them having four-pole, enclosed, cast steel frames, slotted drum armatures and single reduction gear. Experience has shown this type to be the best, and it is an excellent illustration of the "survival of the fittest."

The elevated railway and the suburban road have offered attractive problems to the designers of motors. The first experiments on the New York elevated roads were those of Sprague, in 1886. In 1887 and 1888 Daft experimented almost continuously on the Ninth Avenue road with remarkable success, but the extinction of his company in the struggle for existence put an untimely end to his labors. Not until 1893 was the electric elevated road an assured engineering and financial success, as demonstrated by the installation of the Intramural line at the World's Fair and the Liverpool road. This was followed by the equipment of the West Side Elevated Railway in Chicago. The underground railways of London afforded an excellent opportunity for electricity, and the complete success of their gearless locomotives has demonstrated the peculiar fitness of the electric motor for this variety of work. The adoption of electricity in the Belt Line tunnels at Baltimore, not only added to the force of this demonstration, but has shown the ability of designers to plan motors for the heaviest service.

Somewhat foreign to the title of this paper, but of interest in this connection, is the development of storage-battery traction and the underground conduit. As early as 1885 Reckenzaun had operated accumulator tram-cars in Berlin. Edward Julien had experimented in 1881 and 1882 and by 1885 had made a very successful car, which was brought to this country and operated on the Eighth Avenue road in New York. The motor, of Reckenzaun's design, was bi-polar, with rope belts to a countershaft, and thence sprocket and chain gear to axle. Numerous attempts have been made since to operate storage battery cars, but the inherent defects of accumulators, their weight and their costly depreciation, have not as yet enabled these cars to compete with other electric systems or cables.

The underground conduit has been a most attractive problem to inventors as is shown by the multitude of patents granted for such systems. While the first commercially operated road in America used a conduit, their success was problematical until last year. A considerable system at Budapest has been successfully operated in this way since 1889, but under conditions of climate different from those in this country. In 1893, a short line was installed in Washington, D. C., but its success was not reassuring. The summer of 1895, however, saw the installation of important systems both in New York and Washington. In both cases the work is of the most massive and solid character, both sides of the circuit being carried in the conduit. The construction cost, in both cases, also, was very great, but the entire success of the systems is unquestioned.

The future will probably show little further development of the types of motors now in use. It is probably in the direction of accumulators and the use of alternating or multiphase currents that we must look for radical innovations. The evolution of the street railway motor from its early crudities to the highly perfected machines of to-day in ten years, is a monument to the genius, patience and skill of American engineers.

The Brooklyn Institute of Arts and Sciences.

In order to make brief mention of the numerous teachings and lecture courses of the Brooklyn Institute of Arts and Sciences, for the 1896-7 season, a prospectus of no less than 109 pages is required. The Department of Electricity, of which Mr. James Hamblet is president, and Mr. Henry T. Weed, secretary, will have eight illustrated lectures on current topics of interest in electricity, and in addition, a course of five lectures on the science of electricity, by Dr. M. I. Pupin. The lecturers in the first named course will be Mr. T. Lester Woodbridge, Prof. Samuel Sheldon, Dr. William M. Hutchinson, Prof. E. T. Houston, Prof. W. C. Peckham, Dr. Charles E. Emery, Mr. William Barstow and Mr. Gano S. Dunn. In the Department of Engineering, Prof. R. C. Carpenter will lecture on the "Limitations of Steam and Electricity as Motive Powers".

STEAM ENGINES FOR ELECTRIC RAILWAY SERVICE.

The selection of an engine for electric railway work, more than for any other application of stationary engines, should be based upon a broad, practical, comprehensive grasp of all the requirements—not upon commercial considerations, expediency, prejudice, individual performances or guarantees, but on the results to be obtained by the station as a whole and of which the engine is one out of many interdependent units.

Efficiency, rated power, type, speed, all of these factors are subordinate in the individual unit to the highest—not economy—but *earning capacity* of the station.

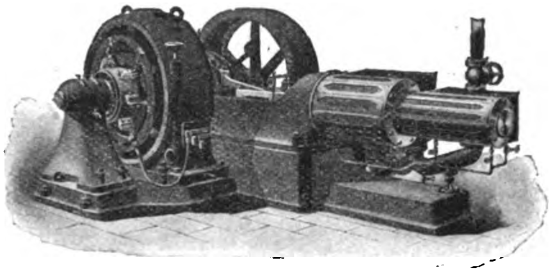


FIG. 1.—WATERTOWN.

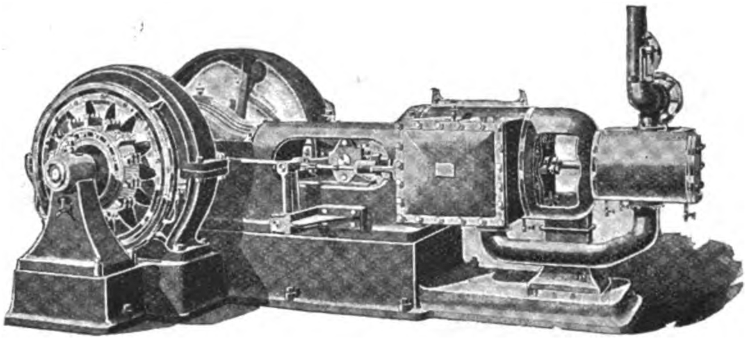


FIG. 2.—MCEWEN.

It must not be understood that any quality, however humble, is to be neglected, but simply that it is to be rated at its proper value in comparison with all the qualities of all the units and not merely with its own.

Engine efficiency is usually an important factor, and an engine is efficient in proportion, first, to the reduction of heat losses due to conduction and radiation; second, to the reduction of clearances; third, to the reduction in friction; fourth, as the valves and pistons are designed to prevent leakage with wear; fifth, to the increase in steam pressure with properly proportioned cylinders; sixth, as the cylinders are properly proportioned to the average load; and seventh, to the personal equation of the engineer.

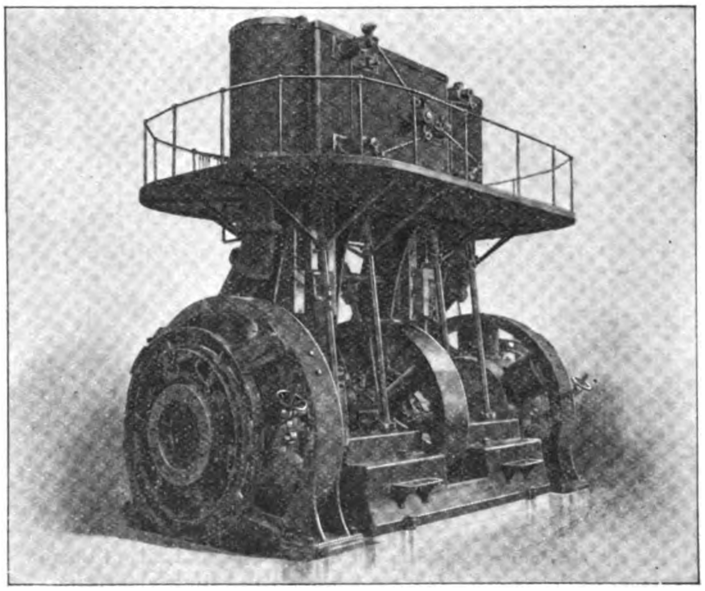
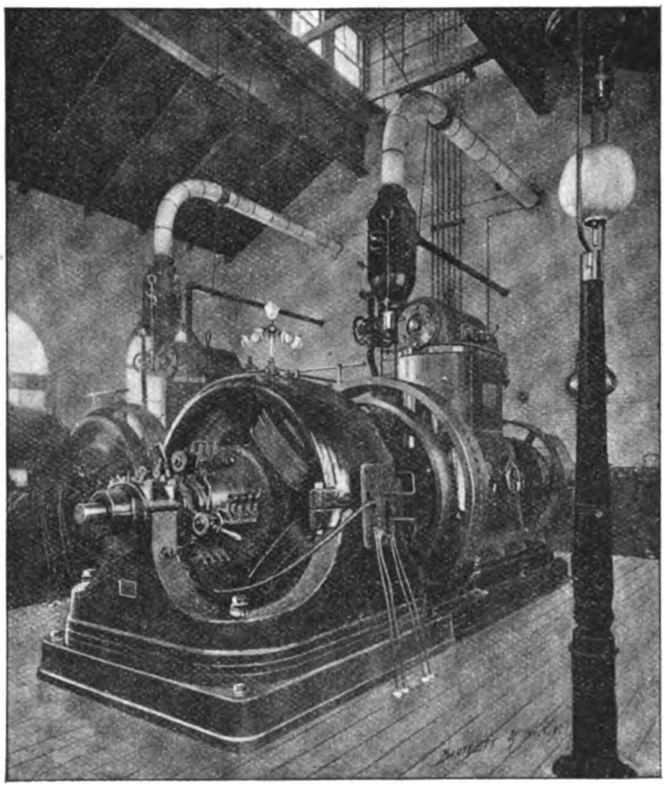


FIG. 3.—BALL & WOOD.



FIG, 4.—WESTINGHOUSE.

The total value of these several factors in engine efficiency cannot be calculated with any great degree of exactness, and the probable value must, for the most part, be determined by a judgment based on experience and knowledge of existing conditions. It is always desirable to avoid complexity, radical innovations and extremes in theories.

The so-called rated power of an engine is principally valuable as indicating at about what load the engine will show its highest steam economy; it bears no necessary relation to the market value of the engine nor to its working capacity. An engine rated at 1000 I. HP may be designed to carry an overload of 10, 20, 50 or 100 per cent., and for short, moderate or indefinite periods—the rated power bearing no relation to the ultimate capacity, the former being based on considerations of steam economy and the latter determined by mechanical reasons.

The type of engine to be selected depends largely upon considerations external to the engine itself after the decision is made as to whether the engine shall be simple, double or triple compound.

The selection may be determined by the shape or size of the power house, the design of the roof trusses, the scheme for piping, the number and type of condensers, accessibility of the generator, personal preferences, conservatism, first cost, or mechanical advantages.

To-day we find a preference for horizontal, side-crank, tandem-compound engines up to about 800 I. HP; from 800 I. HP to 1500 I. HP, horizontal tandem and cross compound are about equally favored; while above 1500 I. HP the cross compound is preferred, chiefly for mechanical reasons. It should be added, however, that there is now a strong leaning toward vertical engines in the larger sizes, and it would undoubtedly be far stronger were it not for the natural conservatism of buyers and the retarding influence of manufacturers who are not prepared to build large verticals, or whose product cannot be easily adapted to the requirements of vertical construction.

Experience and the gradual refinement of engine designs have done much in the past three or four years to bring about a fair degree of unanimity on the formerly much vexed question of engine speed. The general sentiment is tending toward what may be termed *moderate* speeds in contradistinction to what have been termed *high* and *low* speeds; for engines from 300 to 800 I. HP, 150 to 120 r. p. m.; from 600 to 1000 I. HP, 150 to 100 r. p. m.; and from 1000 to 2500 I. HP, 120 to 90 r. p. m. It is not intended to convey the idea that higher or lower speeds are necessarily objectionable, but simply that these speeds in high grade engines give apparently about equal average steam economy with engines of lower speeds, have equal life, cost less and require less floor space.

As a matter of fact, the value of the relation between length of stroke—or speed—and steam economy is a very uncertain quantity. As an interesting and rather remarkable example may be cited the performance of a recently installed 22-in. stroke, 2150-HP, triple expansion engine in the Amoskeag mill, which forms the subject of an article from the pen of Capt. C. H. Manning in the October number of *Cassier's Magazine.*

At about four-fifths its economical load and at 252 r. p. m. this, engine required but 1.38 lbs. of coal per I. HP an hour, this including the coal used in banking and restarting fires, and the loss occasioned by throwing away the water of condensation from cylinder and receiver jackets.

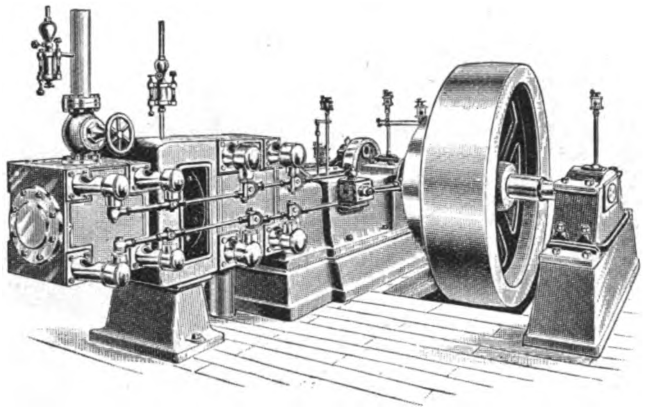


FIG. 5.—ATLAS.

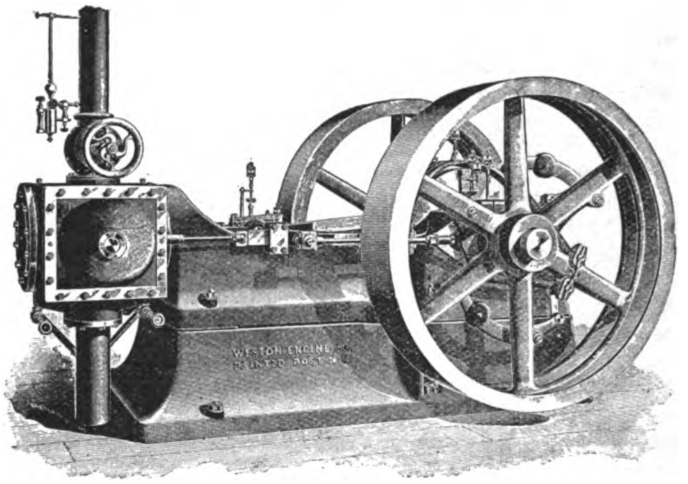


FIG. 6.—WESTON.

Other theories have also suffered in the gradual evolution of engine design and practice. High estimates of the value of cylinder jacketing are questioned, ratios of heating surface in intermediate receivers to engine horse-power vary widely, and there are most conflicting results bearing on the proper ratios of cylinders at given pressures—all of which will ultimately be determined to some degree of exactness by the accumulation of experimental evidence.

In the essential mechanical features of engine design there is already a marked tendency toward uniformity, as an examination of the higher grade of engines will show—not always superficially apparent, but noticeable in the details which go for strength, adjustability and accessibility rather than for appearance.

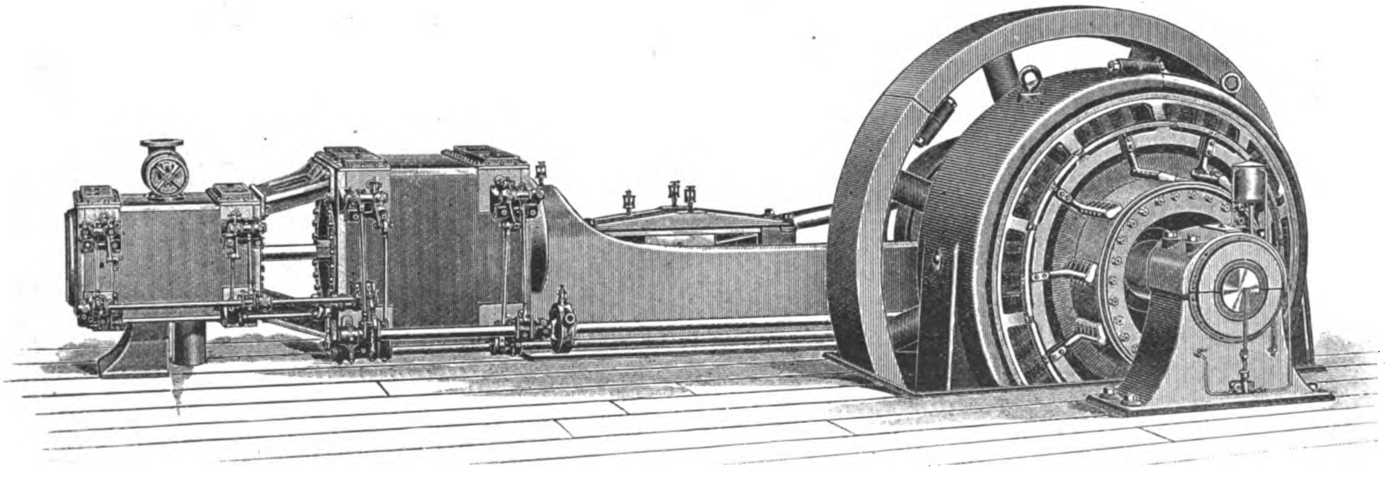


FIG. 7.—MCINTOSH & SEYMOUR.

The engines described below, together with the accompanying illustrations, will give a fair idea of present types of steam engines employed in street railway work. Owing to the limitations of space, the descriptions are somewhat summary, but in future issues we hope to present to our readers descriptions in full detail of some of the types, accompanied by illustrations of valves, governors, etc.

Fig. 1 represents a Watertown tandem-compound engine direct connected to a Westinghouse railway generator. The special advantages claimed for this engine are, first, its substantial, almost massive design, and the solid and heavy construction of all its parts. This is not limited to increasing the weight of the flywheel rims, but is shown in the proportions of the frame, the unusual size of the shaft, the very generous bearings, and the exceptional weight of every part of the engine that encounters strain.

Cards recently taken from a pair of these engines after several years' service show that they are meeting an almost instantaneous change of load, ranging from nothing to an overload of more than 80 per cent., and this without injury and without perceptible variation of speed.

A second advantage claimed for the engine is the arrangement by which the cylinder jacket is extended to cover the space between the cylinders. This not only prevents radiation from the cylinder heads, a point so often neglected, but it also covers the unsightly leakage of steam from glands that may not be tightly packed. The removal of a single panel gives easy access to the stuffing box and cylinder heads. By loosening a few nuts either cylinder is quickly released and either piston removed.

Both valves may be connected with the governor and the point of cut-off shifted simultaneously, or, if preferred, the valves of the two cylinders may be operated by entirely independent mechanism. The working parts of the engine, while easily accessible, are nevertheless as far as possible covered and protected.

The manufacturers direct attention to the method by which the outboard cylinder is supported on its base. This admits of quick and easy adjustment in all three directions, holding the cylinder firmly in position.

Fig. 2 shows the automatic cut-off engine of the J. H. McEwen Manufacturing Company. This type, which was placed on the market in the spring of 1891, is particularly simple in construction. All parts of the engine are made interchangeable, every part being made to gauge. All bearing surfaces are unusually large and are carefully scraped and fitted. This insures long life to the engine, as well as a minimum amount of adjustment. The governor is of a combination inertia and centrifugal design. It will be seen that the inertia and centrifugal weights are combined in the same bar, and it is claimed to be almost impossible to destroy the perfect regulation of this governor, unless by deliberate intent. It requires no lubrication, there being but one bearing, and this of the roller-pin type, the parts being one spring, one weight and a dash-pot. The air dash-pot, and the centrifugal action of the piston of dash-pot is balanced by counter-weight at one end of dash-pot piston rod, so that no lubrication of this piston is necessary.

Perfect regulation is very important in street railway service. The makers of this engine claim that its regulation cannot be surpassed, the engine running at absolutely the same speed under all changes of load and steam pressure so long as there is pressure enough to do the work, and without any tendency to race.

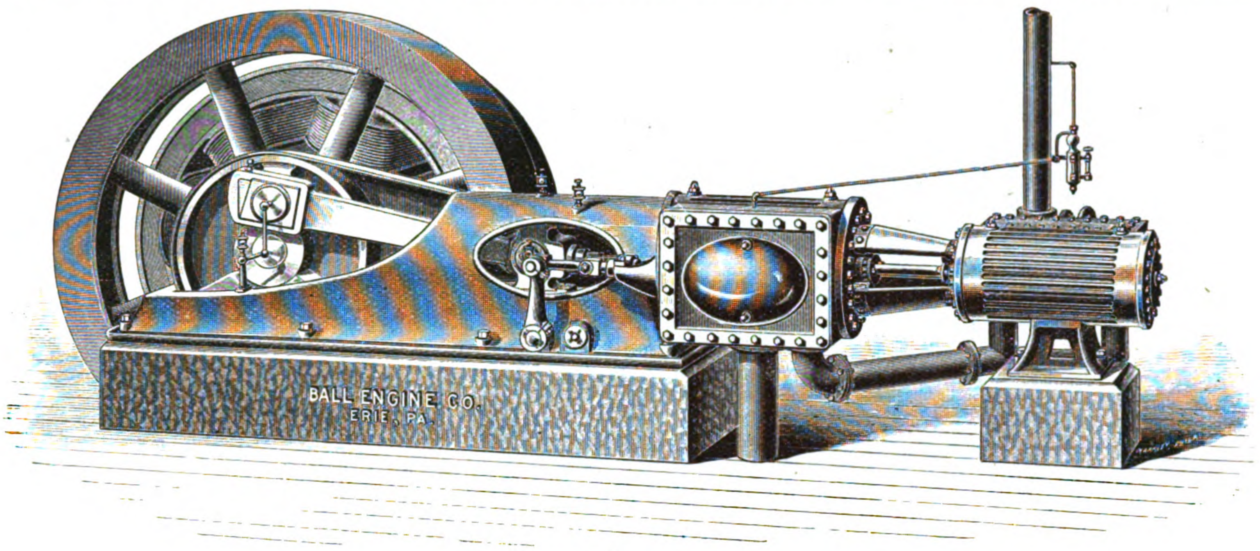

BALL ENGINE CO.
ERIE, PA.

FIG. 8.—BALL.

In Fig. 3 is shown one of ten engines installed by the Ball & Wood Company in the power house of the Edison Electric Illuminating Company at Paterson, N. J. This plant consists of seven 600-HP., vertical-compound, condensing engines, two of 700 HP and one of 450 HP. Eight of these are of the direct-connected type, carrying General Electric generators, one on each end of the engine shaft. The two 700 HP engines are to be used for arc lighting and are connected to the generators by rope drives.

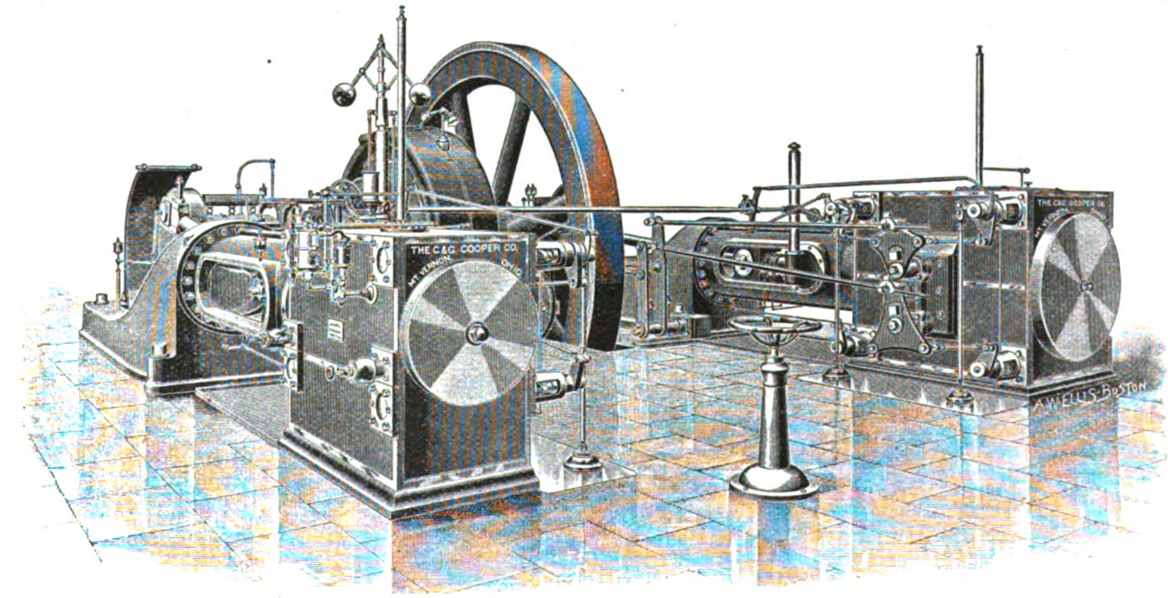

THE C&G. COOPER CO.
MT. VERNON, OHIO
THE C&G. COOPER CO.
A. W. ELLIS-BOSTON

FIG. 9.—COOPER.

The aim kept in view in designing these engines has been to obtain Corliss economy with a relatively high speed, that of the engines being from 140 to 160 r. p. m. To this end, a Corliss type of rotating valve, placed in the cylinder heads, has been used, and instead of a releasing gear, these valves are operated from a wrist plate connected to the eccentrics. The standard Ball & Wood governors are used, fitted in this case, however, with double springs; the regulation has been found very satisfactory, much within one per cent., and it is confidently expected that 15 lbs. of dry steam per indicated horse power per hour will be realized when the plant is in thorough working condition. The same type of engine, of course, is entirely suitable for street railway work.

In Fig. 4 is shown a coupled type of unit, in which the generator rests in its own bearings, the engine being left free to do its own adjustment, a coupling usually more or less flexible uniting them.

This type of apparatus has been largely advocated by the Westinghouse interests, and was first put upon the market by Westinghouse, Church, Kerr & Co., who were very early in the field with this design, which has become familiarly known as the "Kodak," and which involves certain interesting engineering features. In this type the engine and generator stand independently on a heavy bed plate, or, in some cases, simply upon a suitable foundation without bed plate, and the power is transmitted through a flexible coupling, in which the springs are hung from the inside of the rim attached to the engine flywheel, and their other ends attached to a spider of suitable construction on the generator shaft.

This design at once admits of perfect flexibility to counteract misalignment, wear, spring of bed plate or settling of foundation, and gives an elasticity far greater than that obtained from any belt, while at the same time it allows a desirable amount of end play on the generator shaft. This form of coupling transmits power, large or small, and handles widely varying loads, in a particularly efficient manner; the benefits arising from it are chiefly manifest when the apparatus has been in use over a long period of time and the bearings have become worn, as they eventually do in all forms of engines.

The illustration shows a "Kodak" outfit in the engine room of the Fitchburg & Leominster Street Railway, which is laid out with the Westinghouse "Kodak" of 330 HP as a unit, and is operated condensing, with excellent economical and operative results. The illustration gives a fair view of the way in which this design of apparatus lends itself to the arrangement of such an engine room.

This whole design of the "Kodak" is of particular interest in that it involves a type of engine differing widely from engines of other types, and employs the elastic and flexible mode of connection above referred to.

The Atlas "Cycloidal High Duty Engine" is shown in Fig. 5, and is particularly notable from the type of valve and valve gear employed. The cylinders have four valves—two steam and two exhaust—with

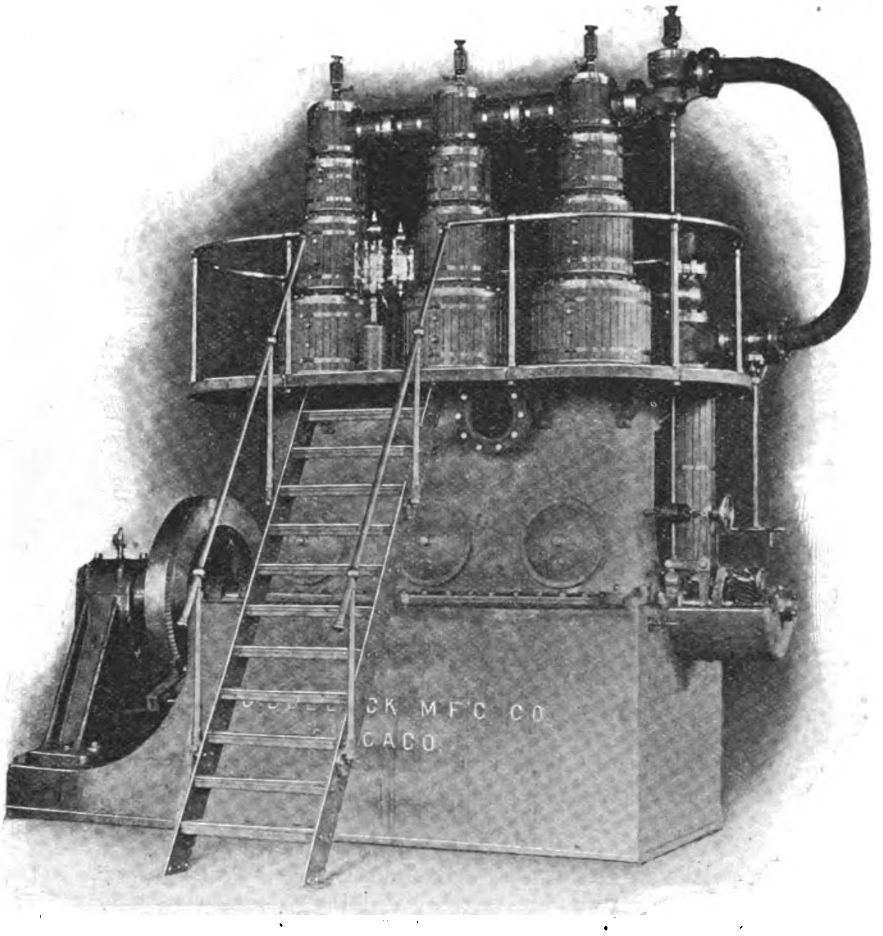


FIG. 10.—WILLANS.

short steam passages and removable valve seats and cylinder linings. The valves are worked direct from the governor and two eccentrics without the intermediary of claws, trips, dash-pots, etc. Both steam and exhaust valves are multi-ported and have a minimum travel.

The exhaust valves are operated by a fixed eccentric; the steam valve eccentric is controlled by a wheel governor with roller bearings. The main feature of the valve gear consists in the manner whereby motion is given to the steam valves. On the end of the valve stem is a roller against which bears a cycloidal cam on a vertical shaft rocked by the valve rod. The inward motion of the valve is given by this cam, and the return motion results from an unbalanced pressure of steam in the valve chest on the steam valve.

The automatic engine of the Weston Engine Company, shown in Fig. 6, has been particularly designed for electric lighting and street railway work, where regulation and efficiency is of so much importance, and is built for connecting direct to the generator and also for belting. The engine is made very massive and strong to withstand the strains due to overloads and short circuits.

Every wearing part has provision for adjustment, so that with proper attention from the engineer there can be no noise in running, even after years of service. Hardened steel is used wherever advisable and every nut is case-hardened. The engine bed is made especially heavy, having interior ribs running across and lengthwise in sufficient number to make it rigid, and proof against any springing tendency. The main bearings are of the quarter-box type with an adjustable cheek piece to take up wear and a cap made adjustable with babbitt liners. The guides are a fixed portion of the bed, planed and accurately scraped. The cross-head is adjustable to accommodate wear of any magnitude, and is so constructed that the piston rod, after being fastened to it, cannot get loose by accident. The reciprocating parts are balanced entirely in the crank disks, the wheels being balanced independently. The cylinder and steam chest are in one casting, and a cast iron jacket allows the cylinder to be covered with mineral wool for the prevention of condensation. The piston is made hollow and grooved for cast-iron packing rings. The crank-shaft and crank-pin are made in one piece from steel, and are provided with detachable counterbalancing disks, no built-up cranks being used by this firm.

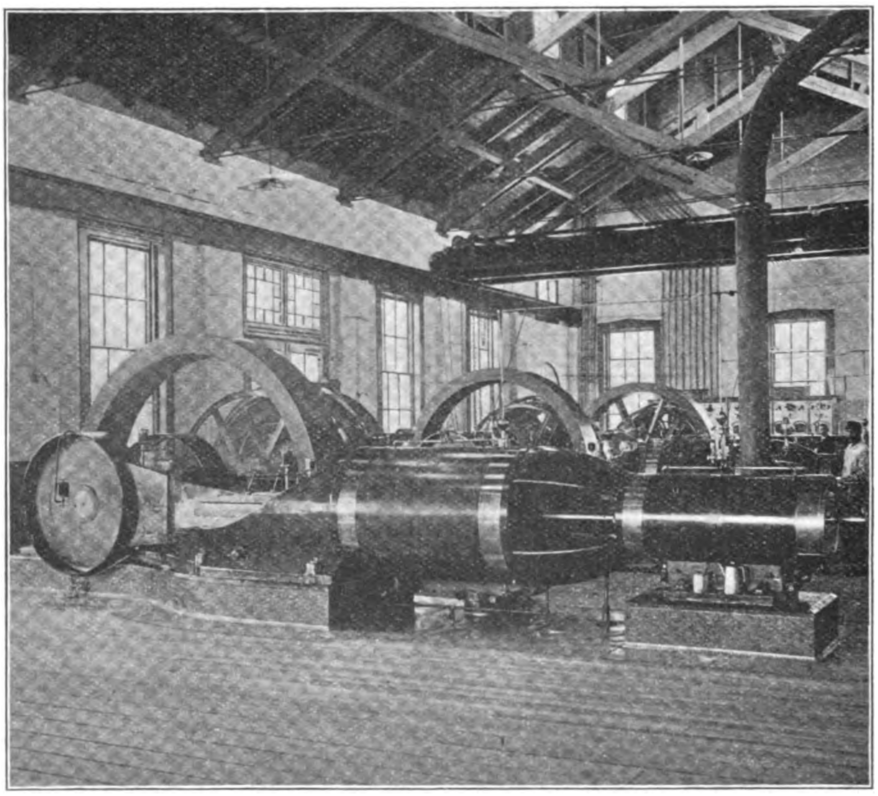


FIG. 11.—BUCKEYE.

The valve is a single casting, with accurately parallel faces, and works steam-tight between its seat and a heavy pressure plate, the entire pressure of steam being carried by the pressure plate, and the valve thus left to work in perfect balance, even under the most extreme steam pressure. The governor, which is of the wheel type, is adjusted by an arrangement which permits of regulation to a degree approaching synchronism, if desired. No dash-pots are used, but the weights so arranged with relation to the weight lever pivots and to the points of attachment to the eccentric that their own inertia destroys any tendency to vibration.

Fig. 7 shows a horizontal, tandem-compound, direct connected railway engine made by McIntosh, Seymour & Company.

Gridiron valves are used on both high and low pressure cylinders, and the clearance is reduced to a minimum, it being claimed to amount to only about one-half the clearance on Corliss engines of the same stroke. The valve gear is positively driven and admits of any speed, the same valve gear being used on engines running at 60 r. p. m., 100 r. p. m., 200 r. p. m. or 300 r. p. m. This valve gear is controlled at every point by the governor, and prevents any possible running away of the engine under any condition of load or any condition of change in load.

The makers claim as a great advantage the fact that the valves are unbalanced, and therefore wear tight, since with most existing forms of valve gear, including the Corliss, the wear renders the valve leaky, causing an increasing loss of economy. At the same time, they state, the valves are easily driven, as they are only in motion when the ports are open and are at rest when the ports are closed, so that the valve gear on the largest engines can be easily handled with the full steam pressure on. The admission valves are double, and move in opposite directions when opening and closing, so that a full opening or closing is obtained with a very slight movement of the valve itself; in a 1000-HP engine the distance is only about 1¼ ins. The method of taking hold of the valve gear by the eccentric is such that angularity is corrected, for there is the same movement of the valve for both ends of the stroke, and for all loads. The governor controls the cut-off both in the high and low pressure cylinders, so that the division of load and the fall in temperature in the high and low pressure cylinders are equalized for all loads.

Between the high and low pressure cylinders a long babbitted sleeve is provided in which the piston rod runs. This serves both as a packing tube, doing away with glands and the constant trouble incident to packing them, and as a long bearing guiding the pistons, keeping them central in the cylinders, and thus avoiding the wear and tear upon the ordinary type of construction. Both ends of the high and low pressure cylinders are provided with automatic relief valves of the pop safety valve type, which serve both as relief valves and as drip valves. Where desired, the high pressure cylinder is steam jacketed, and a receiver of large capacity is provided between the high and low pressure cylinders, this receiver containing coils filled with steam at boiler pressure, thus serving to dry the steam before it passes into the low pressure cylinder.

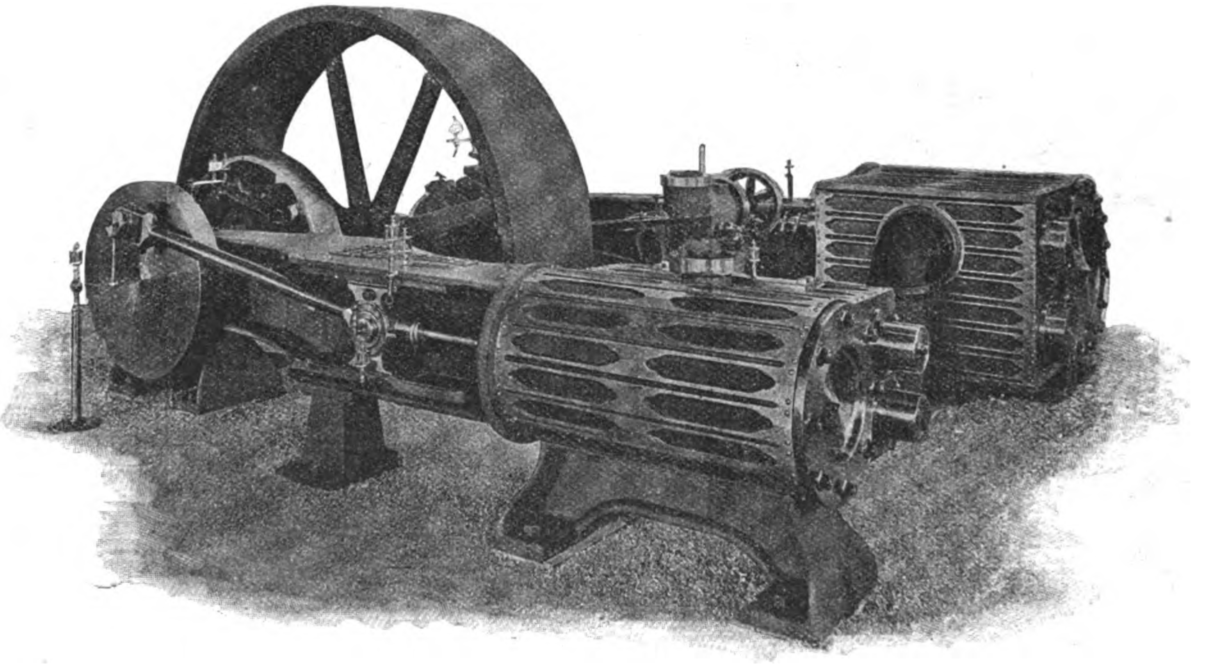


FIG. 13.—FITCHBURG.

All parts of the engine are made to gauge and interchangeable, flat surfaces are scraped to surface plates, and surface and cylindrical grinding used where advantageous. The framing is heavy and massive, stiffened with internal ribbing, and the material so placed that the strains act in a direct manner. The frame below the guides is carried right down to the foundation so that the strains are transmitted direct from the crosshead through the frame to the foundation, and not through the bolts holding the cylinder to the framing.

The makers of this engine are now building a three-cylinder, triple-expansion engine, to be direct connected to a 500-KW railway generator at 120 revolutions.

In Fig. 8 is shown an engine made by the Ball Engine Company, being a tandem-compound, condensing, side-crank engine rated at 300 HP at 180 revolutions. The diameter of the high pressure cylinder is 16 ins. and of the low pressure 28 ins., the stroke being 22 ins.

The governor is in the flywheel, which is 10 ft. in diameter and weighs 15,000 lbs., the total shipping weight of the engine being 55,000 lbs. The crank shaft of the engine is an open hearth steel forging, 11 ins. in diameter in the engine bearing and outboard bearing, and 14 ins. diameter in the dynamo fit. The journal boxes are made up of bottom, top and quarter boxes, lined with removable babbitt metal shells, and with adjustments for all directions, so that the shaft may always be kept in alignment.

The cylinders are made of a special mixture of hard, close-grained charcoal iron, accurately bored to size, both cylinders and heads being made perfectly tight by ground joints. An asbestos covering surrounding the cylinder protects against heat radiation, and a handsome nickel plated jacket covering this leaves a dead air space between.

The adjustment of the boxes, on both ends of the rod, is by means of wedges operated by T-pointed set screws placed in the top of the rod, which move the wedges up and down for adjustment, and as the movement of the wedges is in the same direction, the length of the rod is not changed, nor is the position of the piston altered. These adjustments are made by hand and with a great degree of accuracy.

Each engine has a "Nordberg" quick closing throttle valve. The engine is especially designed for heavy duty work, and has an extremely stout, heavy frame, and large bearings and wearing surfaces.

The valve operating mechanism permits of each valve being driven direct, the high pressure valve and its connections being upon one side and the low pressure valve and its connections upon the other side. This arrangement makes readily accessible the moving parts and avoids complexity.

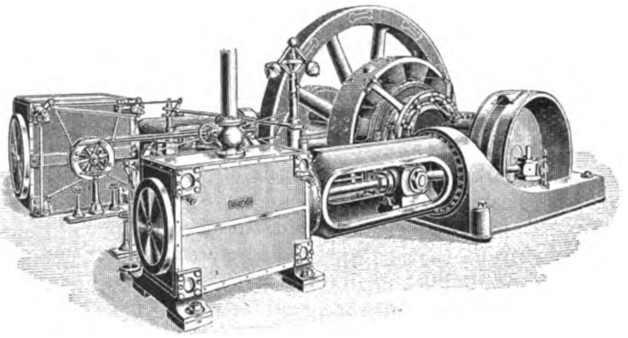


FIG. 12.—ALLIS.

Fig. 9 shows one of the five engines furnished by the C. & G. Cooper Company to the Nassau Electric Railway Company's power station at Thirty-ninth Street and East River, South Brooklyn. The engine, which is rated at 750 I. HP, is direct-connected to a 500-KW Westinghouse railway generator. The type which it represents was especially designed for electric railway work, with semi-tangye bed plate, of extra heavy proportions, and with due consideration given in all the working parts to the severe duty of street railway service.

The high pressure cylinder is 22 ins. bore, the low pressure cylinder 40 ins. and the stroke 48 ins.; the engine runs at 90 r. p. m. or at 720 ft. piston speed. From the cut it will be seen that the steam and exhaust valves are actuated by independent eccentrics, operating separate wrist plates. These wrist plates work on separate centers, making the whole valve gear easily accessible. The governor controls both sets of valves, and a special attachment is provided for the low pressure valve gear, so that the point of cut-off can be adjusted while in motion.

The engine shaft is 16 ins. in diameter in the bearings and 19 ins. in the center. The flywheel is made in segments held together by heavy forged links, and is 18 ft. in diameter, weighing about 65,000 lbs. All the pipes and receivers for connecting the high and low pressure cylinders are in the basement between the foundations. The steam pipes also enter the high pressure cylinder at the bottom, so that the engine room is not obstructed by any piping.

Fig. 10 shows a Willans central valve engine of the heavy duty type, manufactured by the M. C. Bullock Manufacturing Company, which is especially designed for electric street railway work, the ratio of the cylinders and the cut-off being arranged for an extremely large economical range of load. The automatic cut-off is of the relay type, and consequently the governor is small, quick-acting, and has practically no wear, while the power to move the cut-off valves is practically unlimited. The makers claim that the engine is quite capable of withstanding any shock due to all conditions of load, without the introduction of couplings, and that short-circuiting does not affect the engine injuriously in any way, while the load can be thrown off or on as suddenly as is possible. An economy is claimed for this type of engine even exceeding the results of similar sized slow speed or Corliss engine units. The compactness of the combination is undeniably of great value where real estate or buildings are at all costly. The high speed of the engine enables smaller generators to be used, and it can be run continuously for months without shutting down, the system of lubrication throughout being entirely automatic. The makers state that on the compound engine, condensing, a steam economy of less than 15 lbs. has been obtained, and on the triple expansion engines figures as low as 12½ lbs. of water per I. HP. per hour have been recorded under suitable conditions.

Fig. 11 shows a type of engine made by the Buckeye Engine Company, the one illustrated being from a plant of three tandem-compound engines in use by the City Railway Company, of Dayton, O. These engines have cylinders 17½ ins. and 30½ ins. diameter, of 33 ins. stroke, and run at 130 r. p. m. The nominal horse power of the engines is 450 each. They are direct connected to Siemens & Halske dynamos. The valve movement is of the well known Buckeye type, the valves in the high pressure cylinder being round, the independent cut-off valve working within the main valve, while the valves of the low pressure cylinder are flat and of hollow construction, having a flat cut-off valve within the main valve.

These engines are governed by the well known Buckeye shaft governor, and the makers state that they will guarantee a regulation within 1 per cent. if necessary.

The clearance of the high pressure cylinder is about 6 per cent. and that of the low pressure about 2 per cent. The simplicity of the valve gear is worthy of note, and the accessibility of the low pressure cylinder for examination of the piston without removing the high pressure, is an extremely desirable feature.

Fig. 12 shows an engine built by the Edward P. Allis Company. It is of that firm's cross-compound, direct-coupled type, which has been very generally adopted for street railway work. The Allis Company has furnished many engines of this description, ranging in power from 300 to 3000 HP, which are operating on the principal electric roads in the country.

Fig. 13 shows an engine built by the Fitchburg Steam Engine Company, and now in use running the electric railway system of Brattleboro, Vt. The engine, which is of the cross-compound, condensing type, is of 200 HP. The cylinders are 13 ins. and 24 ins. × 20 ins. stroke and 200 r. p. m. The engine has the Fitchburg special cam valve motion with four valves in each cylinder, by means of which a very close clearance and a constant exhaust release and closure are secured with a high resultant economy. The cam valve motion permits any number of revolutions from 60 to 200, and assures such good regulation of

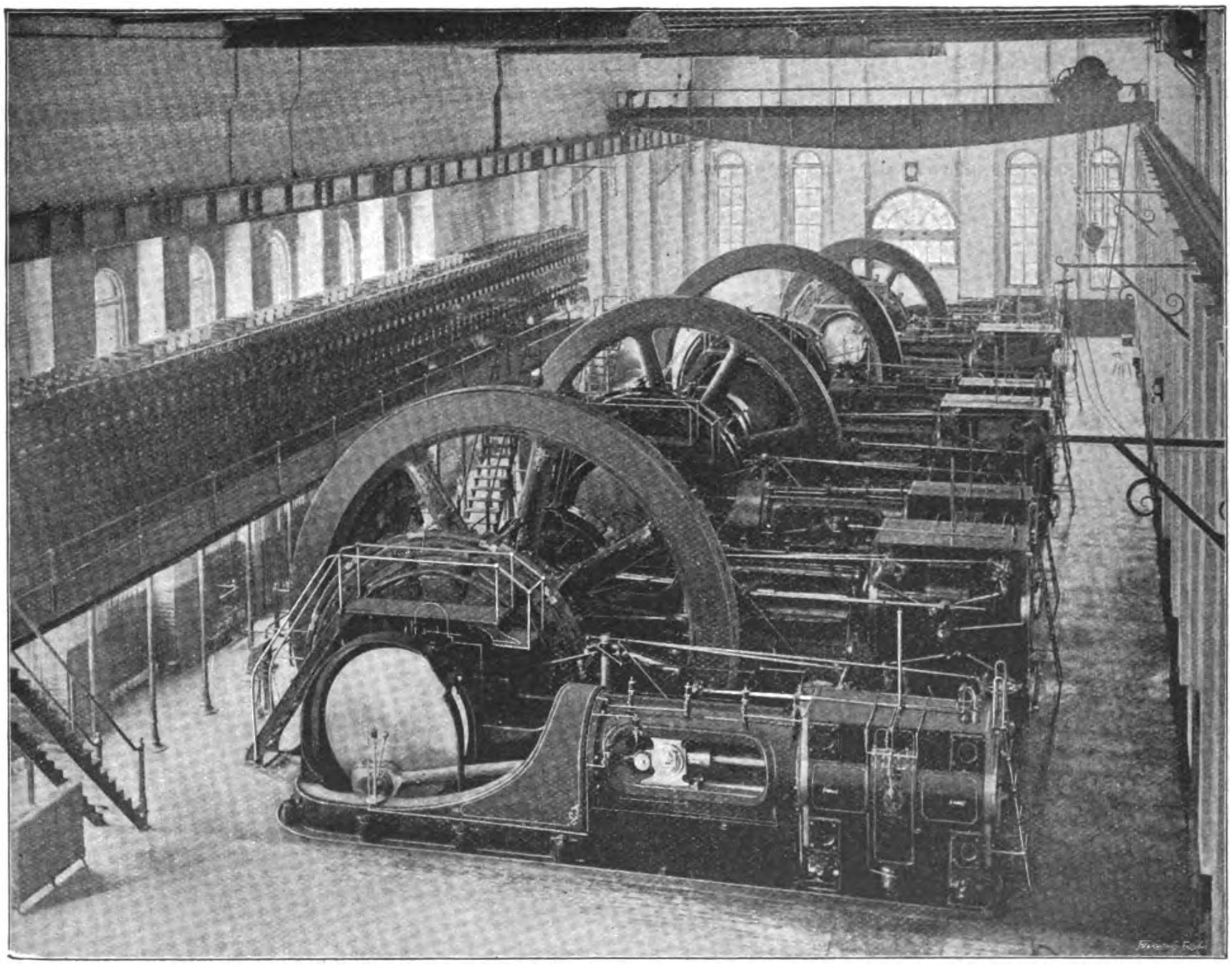


FIG. 14.—FRASER & CHALMERS.

speed, that incandescent lamps and electric railway generators are run from the same engine without the slightest flicker in the lamps, this being also true at North Adams and Gardner, Mass., where the same type of engine is used.

The steam valves are double-ported, giving sharp admission and sharp cut-off of steam, and the whole engine is simple in its construction. The steam valve opens and closes very quickly and then remains stationary while the valve at the other end is being opened and closed. The same makers build tandem-compound engines in sizes from 1200 HP down.

A type of non-condensing compound Corliss engine, made by Fraser & Chalmers, is shown in Fig. 14, which illustrates the new power plant of the West Chicago Railway Company. Three of the engines have cylinders 34 ins. and 54 ins. in diameter with a stroke of 60 ins., and the fourth cylinders of 40 ins. and 48 ins. in diameter with 48 ins. stroke. The large engines make 75 r. p. m. and the smaller one 80 r. p. m.; the rated horse powers are 2000 and 1000 respectively, though the former have on occasions developed 3000 HP. The piston speed of 900 ft. per minute is somewhat unusual for Corliss engines. The plant is worked non-condensing on account of the great cost of water that would otherwise be entailed.

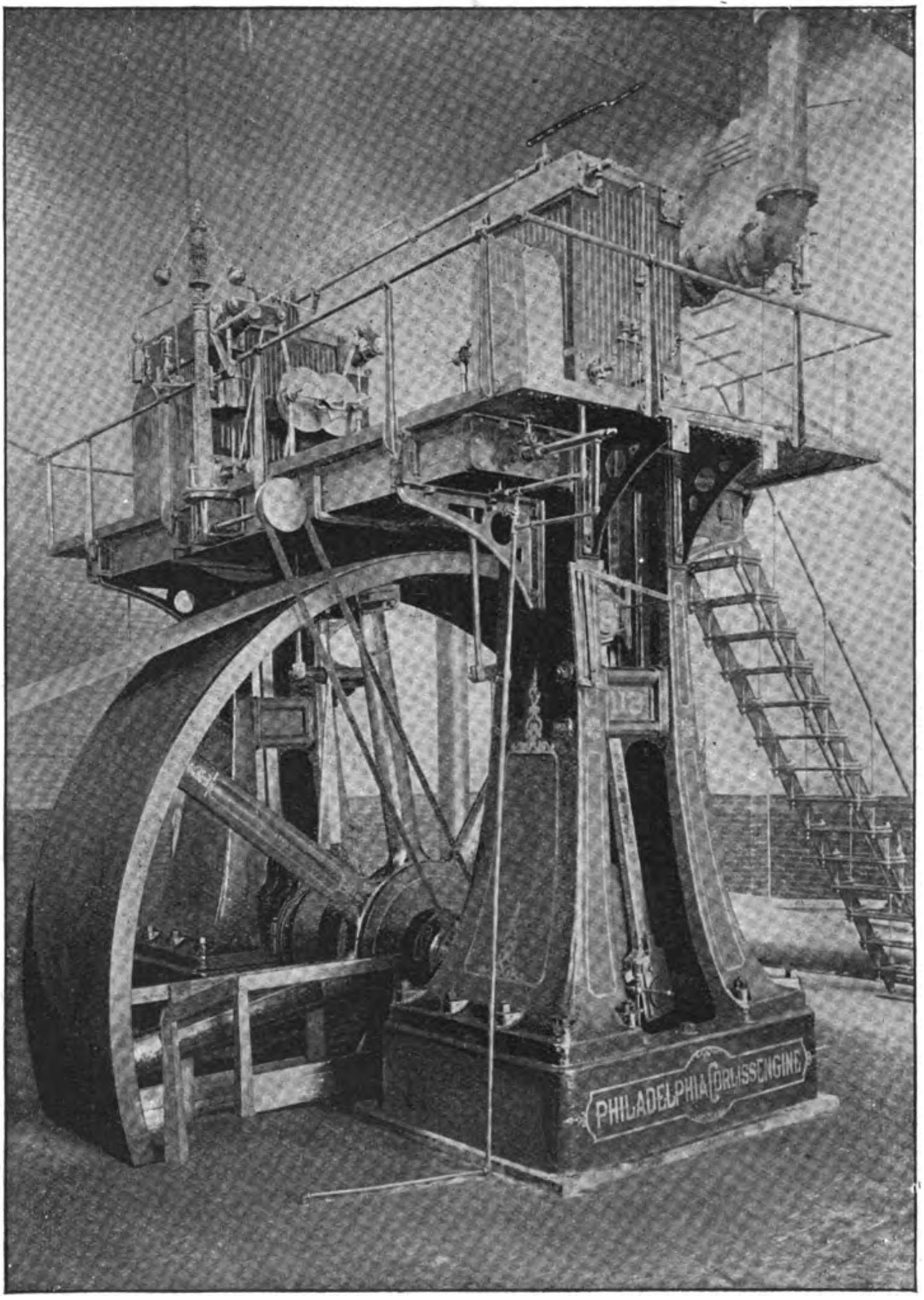


FIG. 15.—PHILADELPHIA ENGINEERING WORKS.

In Fig. 15 is shown one of two Corliss engines built by the Philadelphia Engineering Works, for the Hudson Light & Power Company, of Hoboken, N. J. The same company also recently built three vertical tandem-compound Corliss engines for the Cape Town & South African Electric Railway, possessing many of the features of the engine illustrated.

The Hoboken engines are rated at 500 HP, but will develop 800 HP using steam at 125 lbs. boiler pressure while controlling with the governor by liberating the steam gear of the high pressure cylinder. The cylinders are 20 ins. and 36 ins. with 36 ins. stroke, the the revolutions being 103 p. m.

The shaft journals are 12 ins. in diameter and 24 ins. long. The flywheels are 17½ ft. diameter and 54 ins. face, weighing 47,000 lbs. each and running at a peripheral speed of 5660 ft. per minute. The engines are controlled by a counter-weighted governor of the "Porter" type. The steam when exhausted from the high pressure cylinder, is reheated by being passed through a nest of tubes surrounded by boiler steam.

The National Electric Light Association.

Under the able and energetic executive of President Nicholls, the National Electric Light Association is accomplishing work of the highest value, not only to its members, but to the electrical industry at large. Some time ago an interim report was issued showing that the officers and executive committee were energetically working along several lines of usefulness, from which valuable results were already being returned, and a second interim report more recently submitted by President Nicholls gives evidence that there is no slackening of effort. The report states that a number of new members have recently been added to the Association, and that the compilation of municipal lighting statistics has progressed very satisfactorily, a supplementary report on which having been incorporated with the previous preliminary one, the resulting bulletin being most complete. A committee has been appointed to confer with a similar committee of the American Street Railway Association with a view to the consolidation of the two bodies. The report also states that a practical engineer of high standing has been engaged by the Association to personally visit a number of central stations in the East and West and gather data concerning cost of operation, etc., and his report is expected by President Nicholls to form the most valuable publication yet issued by the Association.

The Weston Voltmeter Used as an Instrument for Measuring High Resistances.

To the Editor of the American Electrician:

SIR:—My attention has been called to an error, due to oversight, in my article on "The Weston Voltmeter Used as an Instrument for Measuring High Resistances" which I would like to correct, by substituting for the sentence beginning on line 10 page 157 the following: "For measuring the insulation resistance of a dynamo or motor, first connect the voltmeter terminals to the supply terminals, thus giving V; now connect one terminal of supply to one terminal of machine whose insulation resistance is to be measured and the voltmeter terminals between the other terminal of supply and frame of machine under test."

Also on same page substitute for sentences beginning on lines 19 and 22, the following: "For measuring the insulation resistance of any line from the ground, measure potential, V, of constant source of supply and connect one terminal of supply to one terminal of line. The voltmeter being connected between the other supply terminal and a connection made to the ground (gas or water pipe); this reading gives us V in the above formula."

A. F. McKISSICK.

AUBURN, ALA.

INCANDESCENT AND ARC LAMPS FOR ELECTRIC RAILWAY CIRCUITS.

Owing to the requirements of insurance rules, electric railway companies are limited in the use of current from their lines for electric lighting purposes. In the case of incandescent lighting, this limitation confines the use of incandescent lamps to lighting cars, power houses and car barns. With respect to arc lighting, however, insurance prohibition extends only to arc lamps for interior lighting, thus leaving open to electric railway companies a wide field for street lighting.

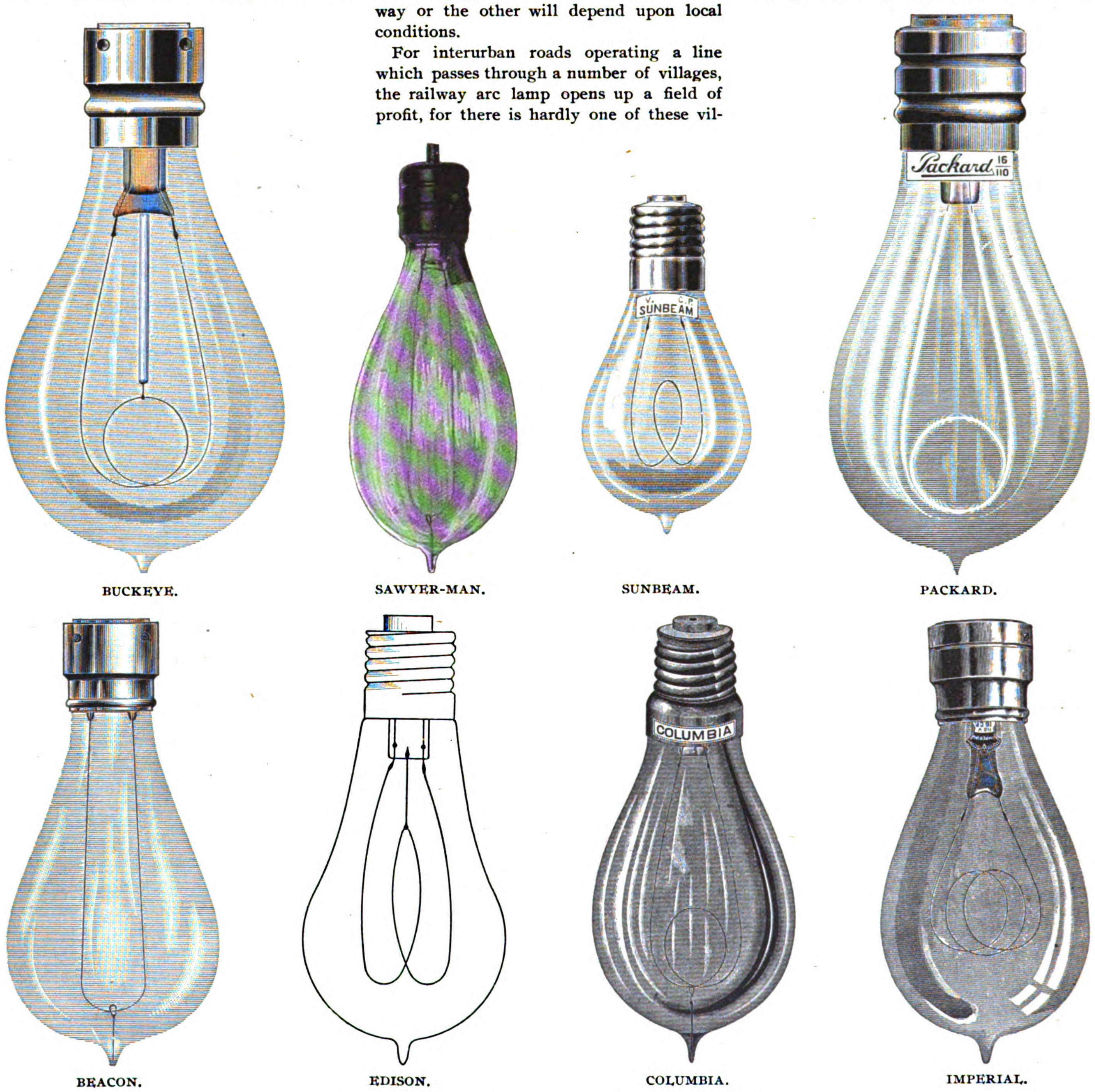

BUCKEYE. SAWYER-MAN. SUNBEAM. PACKARD.
BEACON. EDISON. COLUMBIA. IMPERIAL.

FIG. I.—TYPES OF ELECTRIC RAILWAY INCANDESCENT LAMPS.

Along the line of electric railways arc lighting comes so palpably within the sphere of electric traction companies, that since the introduction on the market of arc lamps fitted for that service, it is, in some cases, merely a question of franchises that intervenes. In addition, since ten arc lamps may be burned in series from a trolley circuit, it is thereby rendered possible in some instances to cover all, or a considerable part, of the more densely populated districts of towns and smaller cities.

Aside from questions of franchises, however, are those relating to the influence of a considerable lamp load during the winter months, when the lighting load line will be superimposed in the evening on the peak of the motor load line. Any increased outlay for additional station and line capacity will also bring up questions whose solution one way or the other will depend upon local conditions.

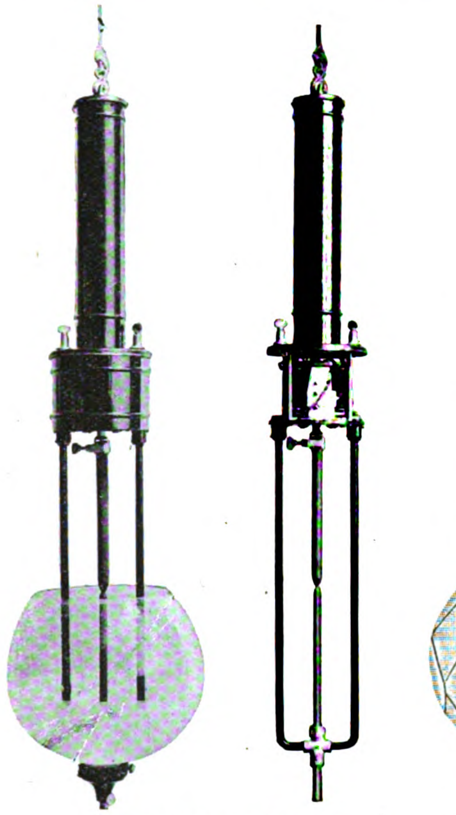
For interurban roads operating a line which passes through a number of villages, the railway arc lamp opens up a field of profit, for there is hardly one of these villages that could not use one or more series of such lamps for street illumination.

Above (Fig. 1) are illustrated the principal types now on the market of incandescent lamps for use in electric railway service, which differ little—in some cases none at all—in shape of filament from the lamps used on ordinary lighting circuits. Some of the lamps have anchored filaments and some not, the question whether an anchor is required being, apparently, one of opinion, or dependent upon the form of filament or conditions of service. Some makers supply both anchored and unanchored filament railway lamps and advise the employment of the former where the vibration is severe.

Owing to the severe service to which incandescent railway lamps are subjected, not only on account of jarring, but through constant variation of voltage, the filament naturally has to be more tough than if used on a constant-potential lighting circuit. This requirement is met by using a thicker filament and burning it at a lower incandescence. This, of course, results in a lower efficiency,—usually four watts per candle power—but in electric railway service the difference is negligible. With such a filament, a good lamp on a trolley circuit will have a life little if any shorter than that of lamps on an ordinary incandescent circuit.

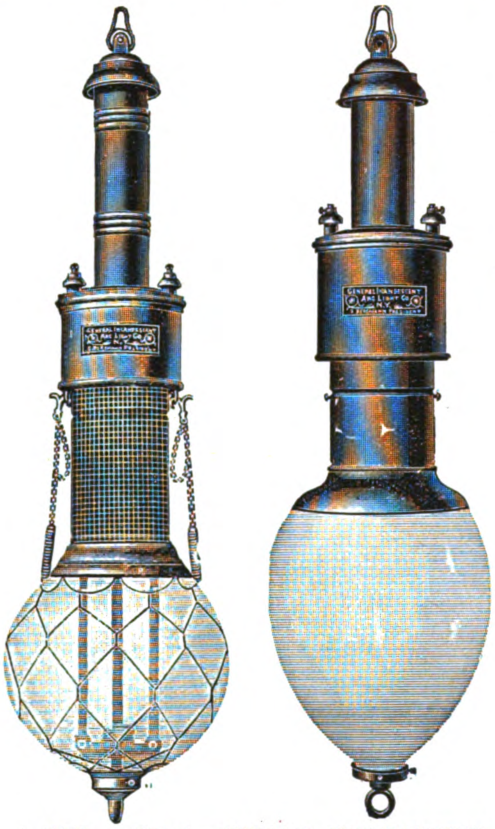
Of arc lamps for trolley circuits, there are two distinct types—the open and enclosed arc, the former operating 9 or 10 in series, and the latter connected 5 in series. Neither of these differs materially from the same types of lamps for incandescent lighting circuits, except by the employment in some of a compensating cut-out; that is, an automatic cut-out which throws in or out of circuit a resistance equivalent to the apparent resistance of the lamp—the resistance being thrown in when the lamp circuit is broken or has an abnormal resistance. Railway, like other constant potential lamps, differ from series arc lamps in having a fixed resistance in circuit to steady the current.

The "Helios" open-arc lamp of the Helios Electric Company, illustrated in Figs. 2 and 3, is adjusted for 8 or 10 amperes, and used nine in series on 450-volt trolley circuits, and ten in series on 500-volt circuits. With each set of lamps the makers supply a resistance in order that the lamp voltage may be exactly adjusted. The lamps are provided with an automatic cut-off, which cuts in or out any arc when the variation in voltage is sufficient to cause such action. There is also an external switch to each lamp to be used in trimming while the lamps are in service. The manufacturers claim that the positive strike of the arc, the method of feeding, the automatic devices, combined with the switch, make the lamp a most desirable one for use on trolley circuits.


FIGS. 2 AND 3.—HELIOS.

The open arc lamp of the General Incandescent Arc Light Company is illustrated in Fig. 4, and the enclosed arc lamp in Fig. 5. The experience of this company has been that the use of a compensating cut-out is not attended with any satisfaction and merely complicates the mechanism of the arc lamp. With a lamp such as it makes now, which cannot very well stick or go out unless the carbon is consumed, it is claimed that the need for a cut-out disappears, and consequently its regular type of constant potential lamp is used for trolley circuits.

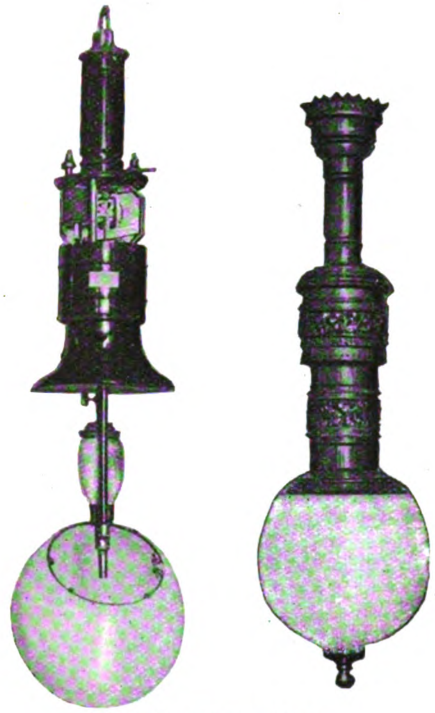
The open arc lamps of this company burn with an arc of 40 to 45 volts and are connected nine or ten in series on circuits from 450 to 550 volts. The mechanism is of the shunt coil type, with rack feed. It is simple and reliable, no springs being used to influence the adjustment and no train of gear wheels, which after a certain time may fail to work. The trimming is accomplished by lowering the globe, which is supported by chains; the carbon holders are arranged to take any size carbon from $\frac{5}{16}$ in. up to $\frac{11}{16}$ in. diameter, clamping them always centrally.


FIGS. 4 AND 5.—GENERAL INCANDESCENT.

These lamps are manufactured in three lengths: "Short," or 37 ins. for 8 hours of life; "Standard," or 45 ins. for 11 hours of life, and "Long," or 53 ins. for 14 hours of life (all night); the regular currents are 6, 8 and 10 amperes. The makers advise the use of a soft cored upper carbon with a solid lower, to obtain steadiness and greatest economy of light.

The enclosed arc lamps made by the same company burn with an arc of about 80 volts, and are connected 5 in series on 500 or 550 volt circuits. One set of carbons in these lamps will last 150 hours of burning, saving in both the cost of carbons and labor of trimming. The feeding mechanism is simple and reliable, no springs or gear wheels being used. The regulation is close and the adjustment cannot change. The trimming can be accomplished with great ease, every single part being separately removable. The length of these lamps is 41 ins. and they take a current of from 5 to 6 amperes. The standard amperage is 5. The proper size of carbons is ½ in. × 12 ins. solid upper, and ½ in. × 5½ ins. solid lower. In retrimming the remainder of the upper carbon is used as a lower.

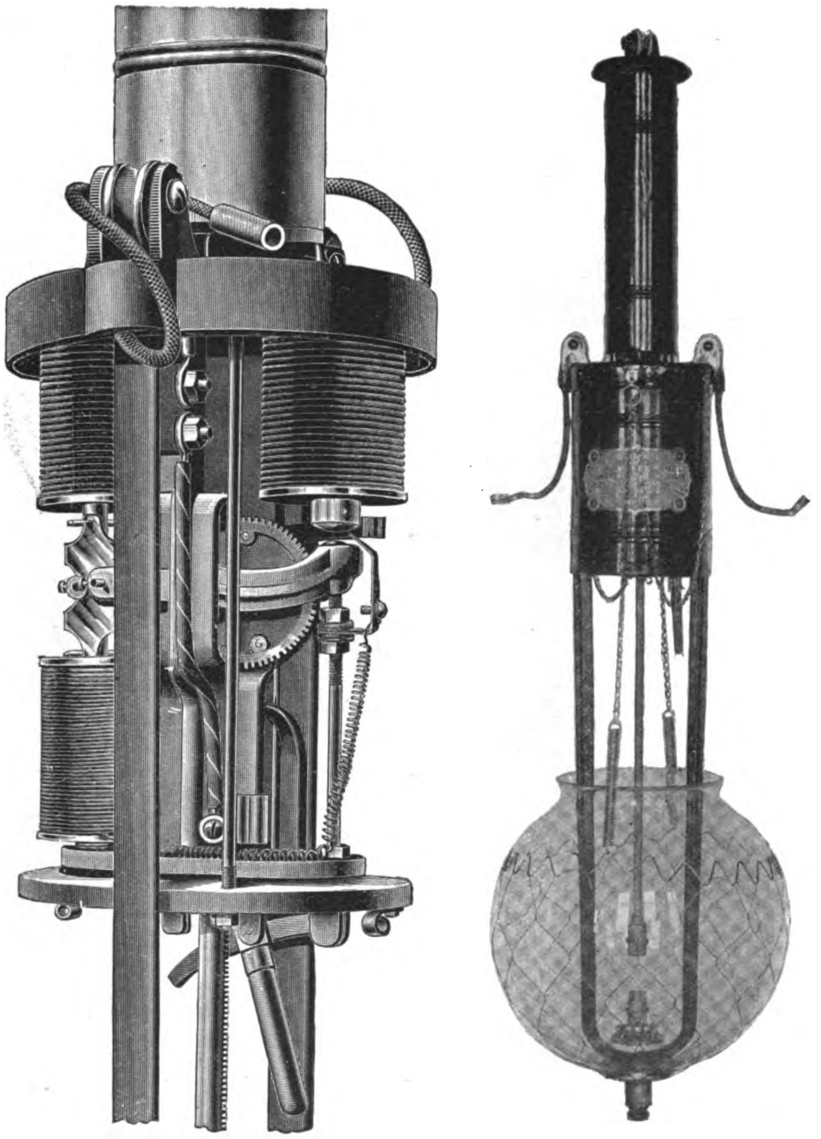
The "Ajax" enclosed arc lamp, made by Pomeroy, Woltmann & Co., is shown in Figs. 6 and 7. In this lamp a rack rod is used by the manufacturers in preference to a clutch feed. The globe holder, which is secured to a single side rod, is so made that the globe drops entirely clear in trimming, thus greatly expediting that operation. One of the principal features of the lamp is the manner in which the arc is enclosed. The arc-enclosing globe rests upon a ground joint base, thus ensuring an efficient joint at its seat. The upper cover consists of a triple valve arrangement, as shown in the illustration, the cover being in three parts of different diameters. The upper one, through which the carbon passes, rests upon an intermediate plate, which in turn seats on the lower plate, the latter being supported by the globe. By this means the entrance of oxygen into the globe is materially retarded, thus assisting the steadiness of the light and prolonging the life of the carbons.


FIGS. 6 AND 7.—AJAX.

The Mosher arc lamp, shown in Figs. 8 and 9, and made by the Adams & Westlake Company, is largely used in street railway work. A rack feed rod is used, and the differential method of control adjusts the feed to the variations of voltage incident to trolley circuits. The mechanism is so arranged that the arc remains steady at all times, there being no jumping or pumping, though no dash-pot or other retarding device is used. The lamp is provided with an automatic cut-out and switch, the resistance for the former being secured in the chimney.

The enclosed arc lamp of the Manhattan General Construction Company is illustrated in Figs. 10, and 11. The "Manhattan" lamp is a radical departure from prevailing types, having a mechanism concentric to the central stem which eliminates the old style of carbon rod and clutch mechanism and substitutes a thin carbon sheath or holder and an arm with a pan attached at its lower end carrying the clutch rings.

The standard outside lamp is shown in Fig. 11 with clear inner and outer globes. The carbon sheath is shown in Fig. 10 being slightly larger than the carbon. The opening in the cap covering the inner globe is of such size as to allow the upper carbon to feed, but will check the sheath when the upper carbon has burned away and the arc gradually lengthens, and finally breaks, cutting the lamp out. Fig. 11 shows the lamp equipped with two clear globes in order to plainly illustrate this feature, and the waterproof brass shell with the rheostat placed in the bottom of the globe, where it is thoroughly protected and easy of access.



FIGS. 8 AND 9.—MOSHER.

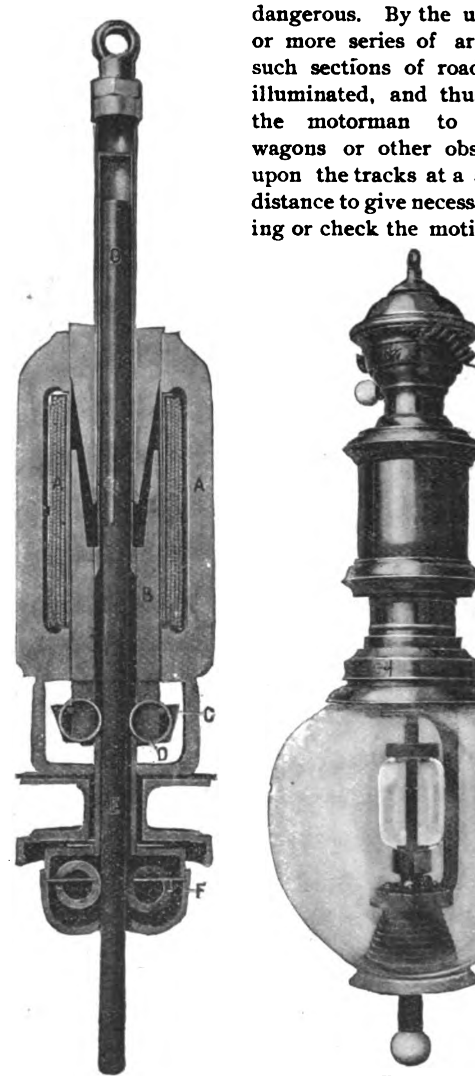


FIG. 1.

FIGS. 10 AND 11.—MANHATTAN.

The outer globe is air-tight at all points except at the bottom, where there is a hand-hole large enough to permit of cleaning and trimming the lamp. This hand-hole is yieldingly closed by a detachable dust-pan. The upper opening of the outer globe is secured to the frame of the lamp and there made air-tight by asbestos gaskets.

The inside globe acts as a chamber of high rarefaction, while the outer globe is a storage for the products of combustion, or a diluting chamber, thus preventing access of air containing oxygen to the carbon points. On the formation of an arc, the enclosed air is heated and rarefied, the surplus air escaping through the lower vent. The contained oxygen is soon reduced by combustion with the carbon points to carbon monoxide, and this, with the remaining nitrogen, surrounds the arc and protects the points from further combustion.

It is found in general use on outdoor lighting, that with the Manhattan lamp the best effects are obtained by using a clear outer and alabaster inner globe, which while giving a perfect diffusion of light, do away with shadows beneath the lamp, and while relieving the strain on the eyes caused by the naked arc, cut off comparatively little light.

This use of the double enclosing globes about the arc, gives a life of 150 hours to one pair of carbons, and is the means by which the arc is maintained at from 80 to 82 volts, in place of a burning life of twelve hours to one pair of carbons at 40 to 42 volts, as in the open air type of arc lamp.

As the upper carbon is only consumed at the rate of one inch in twenty hours and the lower one inch in fifty hours, it will be seen that the lamp seldom feeds, so that aside from the feature of the special clutch provided in this lamp, carbons are required to feed but seldom as compared with lamps which burn in the open air, and are consequently much more steady and regular in burning.

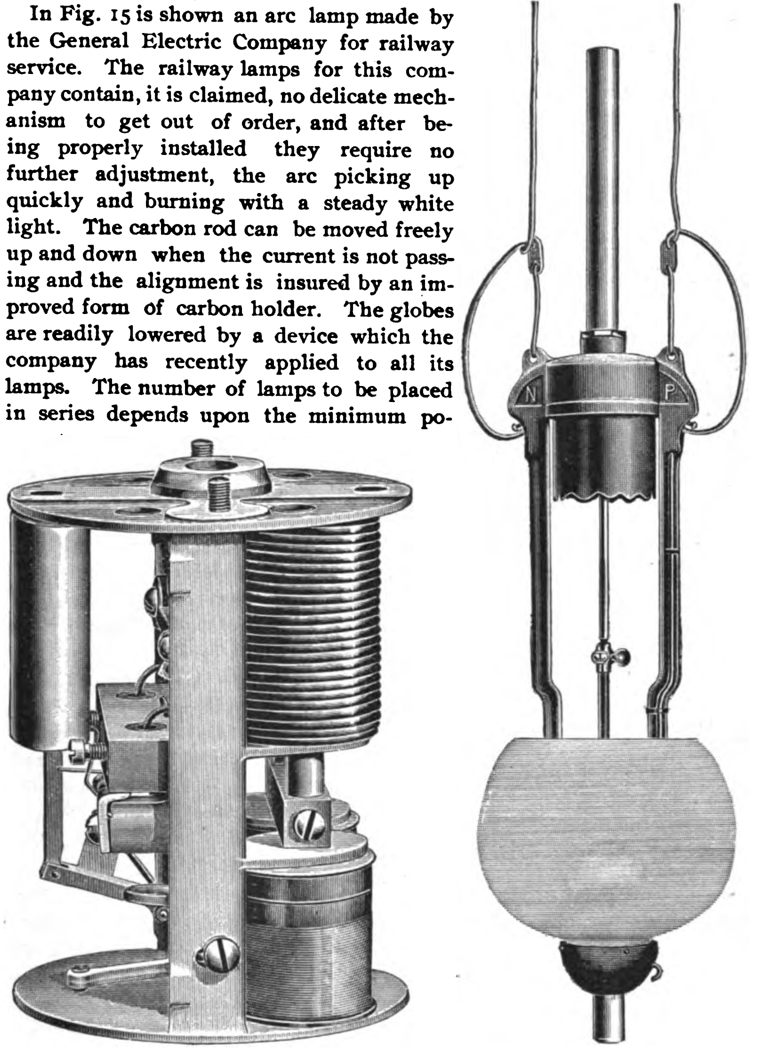
The manufacturers claim that the "Manhattan" lamp is especially adapted for use in street railway work, owing to the fact that five of these lamps can be operated with satisfaction on a circuit ranging from 450 to 550 volts. There are many places on long suburban lines outside of the districts of city lighting where circuits of five lamps can be installed with advantage to illuminate sections of road whereon there is a traffic after nightfall, which, without such illumination makes the running of the cars at maximum speed highly dangerous. By the use of one or more series of arc lamps, such sections of road can be illuminated, and thus enable the motorman to see any wagons or other obstructions upon the tracks at a sufficient distance to give necessary warning or check the motion of the car even when running at the highest rate of speed.

Figs. 12 and 13 illustrate the Waterhouse arc lamp, made by the Perkins Electric Switch Manufacturing Company. These lamps are equipped with a variable resistance, so that, by merely moving a clip, resistance may be cut in or out to adjust the lamp to a given voltage. The frame containing the two terminals and the lower carbon holder, is complete in itself, a detachable brass cage (Fig. 12) containing the magnets, clutch and cut-out. The lower carbon holder is contained in a porcelain insulator in the base of the lamp, thus avoiding insulating washers and securing proper alignment. There are no spring adjustments in the lamp. Each lamp has a resistance equivalent to the apparent resistance of the arc, and an automatic cut-out.

The Electric Arc Lamp Company, whose

"Pioneer" lamp is shown in Fig. 14, is getting out a special line of lamps for railway circuits. The mechanism of this lamp is of great simplicity, consisting merely of a pair of solenoids actuating the clutch mechanism, no springs or other auxiliary mechanism of of any kind being employed. Among the features of the "Pioneer" lamp for which special claims are made are that the lamps require trimming at intervals of only ten days or two weeks, while in some situations with short hours of burning a monthly trimming only is necessary; and that the lamp does not require cored carbons, the ordinary solid carbons being used.

In Fig. 15 is shown an arc lamp made by the General Electric Company for railway service. The railway lamps for this company contain, it is claimed, no delicate mechanism to get out of order, and after being properly installed they require no further adjustment, the arc picking up quickly and burning with a steady white light. The carbon rod can be moved freely up and down when the current is not passing and the alignment is insured by an improved form of carbon holder. The globes are readily lowered by a device which the company has recently applied to all its lamps. The number of lamps to be placed in series depends upon the minimum potential of the line for any considerable time at a point where the branch is taken off. With the carbons which the General Electric Company furnishes, which are of a special make and selected after long experiment, each lamp with its proportionate part of resistance takes 50 volts. Ten lamps, therefore, can be run from a railway circuit with a minimum potential of 500 volts.



FIGS. 12 AND 13.—WATERHOUSE.

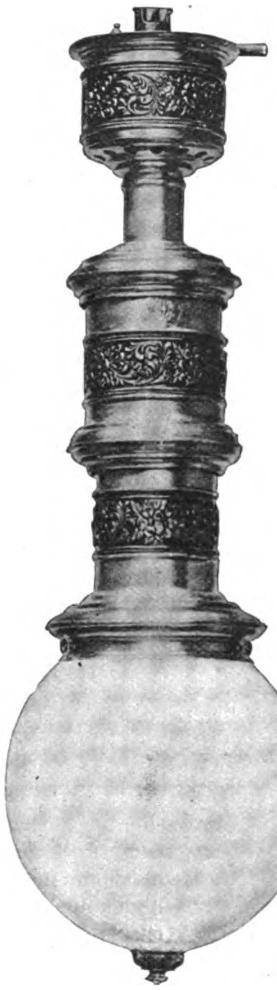


FIG. 14.—PIONEER.

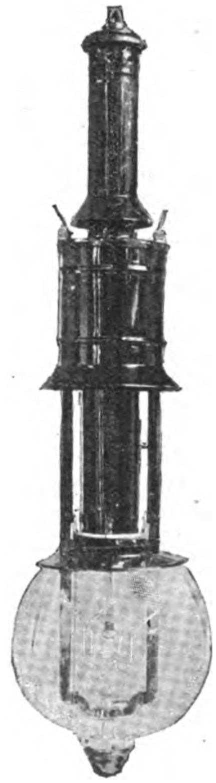


FIG. 15.—GENERAL ELECTRIC.

An adjustable rheostat is placed in each series of lamps, and each lamp is provided with an automatic cut-out to prevent breaking the 500-volt current should the carbons be burned or the arc extinguished from any cause. The cut-out in operating substitutes for the arc a resistance carried in the chimney, which assists in preventing any excess of current.

A special feature of this lamp is its ability to operate satisfactorily in the face of wide variation in the line potential. With $\frac{7}{8}$ in. carbons cored for the upper, and solid for the lower, each lamp will burn about nine hours with nine amperes and 44 volts at the arc, for which current and pressure they are adjusted. We learn that within a short time the General Electric long burning arc lamp will also be adapted to the railway circuit.

THE DISTRIBUTION AND TRANSMISSION OF ELECTRICAL ENERGY.

The presidential inaugural address of Dr. Louis Duncan, read before the American Institute of Electrical Engineers last month, is a contribution of the highest value to the subjects of electrical transmission and distribution of energy, in this respect forming an admirable complement to his inaugural address of last year on electric traction.

After reviewing the considerations governing the generation of electrical energy, Dr. Duncan concludes that for lighting stations, triple expansion engines may be used, while for traction work, where the variation in the load is sudden and may occur after the steam is cut off from the high pressure cylinder, it is not well in general to go beyond compound engines, and there is even a question as to whether simple engines are not more economical when condensing water cannot be obtained. In any case, however, he believes that it is of the utmost importance as regards economy of operation that the load should be made as constant as possible.

As to the use of storage batteries, Dr. Duncan considers that it would be unquestionably more economical in many instances of continuous current, low voltage distribution, to use single stations, to transmit power from these stations to centers of distribution, where batteries may be located, and to distribute from these centers on a three-wire system. A case in point is the system used at Buda-Pesth, where the energy is distributed from the central station to rotary transformers at sub-stations, these rotary transformers feeding batteries, current being distributed from these batteries on a three-wire system. The reports of the operation of this station show that it is both economical and successful, and it might well be copied by some of the companies in this country. The gross receipts of some of the large illuminating companies bear such a large proportion to the company's stock that a comparatively small saving in operation would mean a considerable increase in the dividends, and Dr. Duncan states there is no doubt in his mind that by using one power station, with battery sub-stations for distribution, the operating expenses can be considerably decreased.

As far as traction stations are concerned, their efficiency and output would be increased by the use of batteries, both because the machinery would be steadily loaded and because the most efficient type of apparatus could be used, as is the case in lighting stations. If storage batteries are used, the two types of variable load belonging to lighting and power stations demand different types of battery. For lighting stations a considerable capacity is required, while the momentary variations of power stations do not require any great capacity, but demand as great a maximum output as battery manufacturers can obtain.

In water power plants the conditions of economy are different. The location of the plant is, of course, definitely fixed, and the advisability of obtaining a uniform load by means of batteries, depends upon the local conditions. If the water power is limited and is less than the demand, then it might be well to use batteries in order to increase the amount of salable power. Again, if the development is expensive, it might be cheaper to develop a smaller amount of power, pay for a smaller amount of machinery and increase the output by the addition of batteries.

Dr. Duncan believes that while the practice in large lighting and traction systems is to multiply stations near centers of consumption, yet the economy of a single large station makes it important to consider whether it is not possible to concentrate the power at some point where the expenses will be a minimum and distribute by some of the methods which have in the last few years proved successful and economical. It is important to make the station load steady, and this may be done for continuous current lighting and traction plants by means of storage batteries.

Name.	Type.	Distance in Miles.	Line Voltage.	Horse Power.	Remarks.
Ouray, Col	Direct.	4	800	1200	Successful, increasing.
Geneva, Switzerland	"	20	6600	400	Successful.
San Francisco, Cal	"	12	8000	1000	Successful, 9 years.
Brescia, Italy	"	12	15000	700	
Pomona and San Bernardino	Sin. phased Alt.	13½ to 28¾	1000	800	Successful, increasing, 4 yrs.
Telluride, Col	"	3	3000	400	To be increased, 3200 H. P.
Bodie, Col	"	12½	3400	160	Successful.
Rome, Italy	"	18	6000	2000	Increasing to 9000 H.P. 3 yrs.
Davos, Switzerland	"	2	3660	600	Successful.
Schongeisung, Germany	"	4½	2600	820	"
Springfield, Mass	2-phased Alt.	6½	3600	820	"
Quebec, Canada	"	8	5000	2130	"
Anderson, S. C	"	8	5500	200	"
Fitchburg. Mass	"	2¼	2150	400	"
Winooski, Vt	3-phased Alt.	2½	2500	150	"
Baltic, Conn	"	5	2500	700	"
St. Hyacinthe, Canada	"	5	2500	600	" 2 years.
Concord, N. H	"	4	2500	5000	" 2 years.
Fresno, Cal	"	35	11000	1400	" to be increased.
Big Cottonwood to Salt Lake City, Utah	"	14	10000	1400	"
Lowell, Mass	"	6 to 15	5500	480	"
Sacramento-Folsom, Cal	"	24	10000	4000	1 year.
Redlands, Cal	"	7½	2500	700	3 years, extending lines in other towns.
Lauffen to Frankfort, Germany	"	100	30000	300	(Experimental.)
Lauffen to Heilbronn, Germany	"	9	5000	600	Successful.
Oerlikon Works, Zurich, Switzerland	"	15½	13000	450	"
Portland, Oregon	"	12	6000	5000	"
Silverton Mine, Col	"	4	2500	400	" to be increased.

In considering the question of electrical transmission systems, Dr. Duncan states, that with respect to the relative cost of copper in the line for a given amount of power transmitted and for a given maximum potential between the conductors, the relative amounts for the continuous current and the different alternating current systems, will be as follows:

Continuous current	100
Single-phased alternating	200
Two-phased "	200
Three-phased "	150

The continuous current has thus a marked advantage over the alternating current systems as far as the cost of copper is concerned. There are, however, certain practical disadvantages belonging to this system. The high voltages necessary for long distance transmission make it impossible to distribute the current at the receiving end without first reducing the voltage. With continuous current this can only be done by employing a rotary commutator of some kind. It has not been found possible to make either continuous current dynamos or motors of any great output, as there are practical difficulties in running dynamos of high potential where the current taken from them has a considerable value.

It is necessary, no matter what the voltage is, that both the dynamos and motors shall be directly subjected to it, and this with commutated machines will always be a source of danger. If we are to do any considerable amount of lighting from such a station, the energy for this purpose undergoes three transformations before it reaches the lamps, and the efficiency would not be so high as in a corresponding alternating current system. It would hardly be possible to supply motors for ordinary work at the high voltages used for transmission, and the current for them would have to be transformed in the same manner as the current for the lamps. It must be recognized, however, that this system has been successfully used and has given excellent results in a few cases of transmission.

Dr. Duncan considers that in poly-phased work, two-phased machines with the separate circuits wound on different armatures have the advantage. It has been shown by Mr. Scott, and others, that it is possible to transform a two-phased into a three-phased current, to transmit it and to transform it back again to a two-phased current. This will allow us, if we wish, to use two-phased dynamos for generating the current, to transmit with the advantage incidental to the use of three-phases, and at the reducing end to use two-phased circuits for transmission. This has some advantages as far as balancing the voltage on the circuits goes, and it has been proposed in the case of several plants whose installation is being considered.

The conclusions of Dr. Duncan as to the value of alternating transmission as against continuous current transmission, are that there is a gain in the simplicity and safety in the transmission, and at the distributing end the use of poly-phased currents enables us to supply both lamps and power with an economy and success comparable to that of the continuous current system. If it is necessary to use continuous currents for certain types of distribution at the receiving end, they can be obtained by the use of rotary transformers, by which the alternating current is transformed into a continuous current. These machines have approximately the efficiency of corresponding continuous current dynamos, while the output for a given size is about fifty per cent greater.

The paper contains the accompanying table, giving a partial list of the principal transmission plants that are now in operation.

It will be seen that the longest transmission is at Fresno, Cal., the distance being about 35 miles. The highest alternating voltage used is 13,000 volts at Zurich, Switzerland. The highest direct potential is 15,000 volts at Brescia.

All of these plants are working successfully, and this fact will lead to still longer transmission and higher voltages. No limit of either distance or potential has yet been reached. If we consider the record of the present transmission plants, we can safely say that it would not be going outside of the safe limit of development to transmit at least 50 miles at a potential of 20,000 volts, provided the energy could be delivered at such a price as to be considerably lower than the cost of a corresponding amount of energy obtained from a steam plant. This, of course, is a matter of local condition entirely, and the commercial value of such a transmission will depend upon local conditions.

The final conclusions of Dr. Duncan, subject always, he states, to the influence of local conditions, are as follows:

1. In both direct current lighting and traction systems, where the power is generated in or near the area of distribution, it is best to use one station situated at the most economical point for producing power.

2. In the case of the traction systems, when the economical area of direct distribution is passed, boosters should be employed directly or in connection with batteries, to a distance of ten or twelve miles from a station; beyond this, rotary transformers, whether with or without batteries, should be used.

3. In the case of direct current lighting systems, the energy should be transmitted to storage batteries situated at centers of consumption, either directly or by means of a rotary transformer, and distributed from them

4. Where batteries are used, it is best to place them at the end of feeder wires to obtain the advantage of a constant load on the wire.

5. The best system for the long distance transmission of energy, for general purposes, is the three-phased alternating system.

6. Commercial transmissions are in successful operation for distances of 35 miles, and for voltages as high as 15,000 volts. Experience with these plantsshows that the transmission to 50 miles with a pressure of 20,000 volts is practicable; beyond these limits the transmission would be more or less experimental.

NOTES.

Economy vs. Economy.—A writer in the *American Machinist* relates an instance of a steam engine in which lack of steam economy was considered decidedly economical. While the engine of a planing mill was being overhauled in a machine shop, the superintendent, knowing that the engine had considerably more power than required, fitted a cut-off plate to the main valve to increase the rate of expansion. The cut-off was, however, only used a single day, the objection being that it prevented the engine using enough steam. It seems that the shavings made in the mill were used under the boiler, and to keep the cut-off going it would have taken an extra team of horses to dispose of the fuel saved.

An Old Electrical Firm Embarrassed.—Almost everyone in the United States interested in electrical pursuits knows of the firm of The E. S. Greeley & Company, and all will doubtless regret the financial embarrassment which recently led to this old and highly regarded house passing into the hands of receivers. The business was established forty years ago by L. G. Tillotson, and has been conducted under its recent name for the past twelve years. During the entire period of its existence the house has enjoyed in an unusual degree the esteem and confidence of the electrical public. It is reported that the company may be reorganized and placed under the management of Mr. T. J. Smith, for some years the efficient manager of the electrical department of the company.

The University Scientific Magazine.—The University of Tennessee is represented among college scientific periodicals by *The University Scientific Magazine*, which is published by the Engineering Society of the University. The current number contains an interesting article by Dr. Chas. A. Perkins, Professor of Physics and Electrical Engineering, on "Hertz' Experiments on the Electromagnetic Theory of Light." Other articles on electrical subjects are "Test of an Isolated Electric Lighting Plant," by S. A. Beyland and "Experiments With a Differential Wattmeter," by A. B. Reynders. The feature of the number is an article containing specimens of freehand lettering contributed by almost a score of chief draughtsmen in different large manufacturing establishments of the United States. The specimens are particularly interesting from showing the wide difference of taste that exists with respect to such lettering.

A Standard Incandescent Lamp Socket and Base.—At a recent meeting called by President Frederick Nicholls of the National Electric Light Association, and attended by representatives of the lamp manufacturing companies and others interested in the subject, the matter of a standard incandescent lamp base and socket was discussed. The opinion was unanimously in favor of such a standard, and a resolution was passed designating the Edison socket and base as the most desirable. The result of the meeting was the appointment of a committee composed of Messrs. F. S. Terry, C. H. Rockwell, W. C. Bryant and Chas. I. Hills, to confer with the owners of the socket patents with a view to arranging for their general use. The outcome of the meeting promises well toward attaining a much desired end, and the electrical industry is under obligations to President Nicholls for finally removing the subject from the plane of discussion, where it had lingered for so many years, to that of action.

Growth of Electric Power Applications.—The economy and efficiency of electric power is perhaps most forcibly demonstrated by the extent of the orders placed for power apparatus, for it may be confidently asserted that greater engineering talent and closer examination are brought to bear upon electric power apparatus than upon apparatus of any other order. The great growth in this department, as illustrated by some figures recently compiled by the General Electric Company, is therefore most significant of the results that have been achieved in this field, while the great promise for the future is indicated by the steadily increasing rate at which the out put is growing. The figures referred to are as follows:

	1892.	1893.	1894.	1895.
H.P. .	13,719	18,762	42,379	46,727

In 1896 the missionary work of the past four years began to come to rapid fruition. From Jan. 1 to July 31, the total horse-power of electric power apparatus sold by this single company amounted to over 48,000 HP. During the same period in 1895 the aggregate orders amounted to 25,737 HP. From Aug. 1 to Aug. 18 the total amount of power apparatus ordered during 1896 was increased to the respectable figure of 62,164 HP. The above does not include electric railway motors.

The Metric System.—After a somewhat heated discussion, the Engineers' Club of Philadelphia, by a large majority adopted a petition to Congress in favor of the compulsory establishment of the metric system in this country. The opposition confined their arguments principally to the matter of the cost of the change to the metric system, that would be entailed in manufacturing establishments from the necessity of purchasing new standards, changing tools, etc. Herbert Spencer has written a letter to the London *Times* opposing the metric system, his point of view being naturally that of the evolutionist. His arguments are, first, that though mankind has always had the decimal system at their finger ends and used it for counting, in the course of civilization they departed from it and gradually adopted, instead, systems admitting of easy aliquot divisions; second, that the metric system was not adopted in France on account of its convenience, but through stress of law; third, that in the United States the stock exchanges have substituted for decimal divisions a system of easy aliquot parts; fourth, that though the early men of science and the modern men of practice are at one in recognizing the importance of great divisibility, it is proposed to establish in the metric system a form and measure characterised by relative indivisibility. The above statement entirely evades the two great advantages of the metric system, its convenience in calculations and the fact that it offers the only hope of securing a common system of weights, measures and values for the entire world.

Electric Lighting of Small Towns.—The AMERICAN ELECTRICIAN calls attention editorially to that all-important matter of the use of the incandescent *versus* arc lamps for lighting villages and small towns. It is complained that usually the question is not gone into so thoroughly as it should be by those who have to decide upon the system to be employed. Our contemporary believes that arc lighting is often adopted because "a less glaring system of illumination might be considered to indicate a spirit too retiring on the part of the community employing it." Such may or may not be the case in the States, but we think that if incandescent electric street lighting were sufficiently satisfactory in regard to economical and steady working, and could be thoroughly relied upon, such a consideration would not weigh to any large extent with us in this country. The journal in question holds that in villages and residential thoroughfares in small cities the arc lamp is not in keeping with the surroundings, and also that it is "less efficient than incandescent lighting, both economically and optically." In a few of our English provincial towns and villages this is recognized, and the less important thoroughfares in Brighton and other places are lighted by means of incandescents, and, we believe, are giving satisfaction. The expense and unsuitability of arc lamps for lighting the side streets of the City of London appealed to the minds of the City Commissioners, and the matter has been under consideration for a great while, experiments being carried out to decide which is the best method to adopt. "For towns and smaller cities," adds our contemporary, "the ideal method of illumination is by the incandescent series system for residence streets and outlying districts, with arc lights for the main business streets, which latter lights may be employed only during business hours, circuits of incandescent lamps replacing them after the stores have been closed. As to the relative cost of arc and series incandescent lighting, let us assume that a 1200-CP arc costs $80 per year, and that the annual cost of a 24-CP incandescent lamp is $14 per year. The lower hemispherical intensity of a 1200-CP arc will not average over 300 CP, which is equivalent to a cost of $6.40 for each 24-CP of light; but the average efficient illumination over the territory served will be less than with the same candle-power in incandescent lamps, on account of the better distribution of the light from the latter. This comparison takes into consideration the waste of light in the immediate vicinity of an arc through its too great intensity, but does not consider the blinding effect on the human eye when subjected to such great variations of illumination as are incident to arc lighting when the lamps are widely spaced." The costs given by our contemporary for arc lights could not apply to this country, where the usual charge per lamp per annum is between £20 and £30.—London *Electrical Review*.

ESTABLISHED 1889.

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The Street Railway Convention.

The St. Louis convention of the American Street Railway Association promises to be one of the most successful in the history of that body. The belief currently held that the coming presidential election will usher in a new era of business prosperity, has acted as an incentive, and led to the incurring of expense on the part of manufacturers and others, that otherwise might not have been thought justified by the present state of the street railway industry. One matter to which it is hoped attention will be given at the St. Louis convention, is with respect to extending the usefulness of the Association in a technical sense, by providing for investigations relating to economy of operation. A number of important questions relating to types of steam engines, superheating, auxiliary storage battery power, the employment of alternating currents on interurban lines, etc., might well be made subjects of study for committees, the latter to possess authority to employ expert assistance in their labors.

◆

Electric Lighting Plants for Country Residences.

A branch of electrical work which promises a considerable expansion in the near future is the lighting of country residences. The public interested is beginning to get educated up to the point of believing that their former fears as to the complication, and expert knowledge required in the operation of isolated installations, are unfounded in view of the favorable experience of those who have made the trial. Two important articles on this subject, unavoidably crowded out of the present issue, will appear in our next number. One of these deals with the general considerations applying to the selection and installation of electric lighting plants for country residences, together with practical information as to their operation; the other is a description and method of operation of a 100-light plant of this character, which has been in successful operation for several years without expert attendance, at present being in charge of a sixteen-year old boy.

◆

Electric Lighting from Railway Circuits.

To what extent commercial lighting from electric railway circuits may in the future be done is problematical. Owing to insurance regulations, such lighting will have to be confined outdoors, and while this narrows the field to arc lighting except in special cases, the opportunity for profit, where such an opportunity exists at all, is left one worthy of consideration. Aside from the controlling question of franchise, the main consideration is the reserve of plant capacity required on account of the lamps being in winter lighted during the evening hours of maximum traffic. On suburban and interurban lines, there are, however, cases when outlying districts and villages may be supplied at a good profit and without appreciably affecting the load curve, with the few lights necessary to meet their requirements. From the article in another column it will be seen that manufacturers are now in a position to supply arc lamps entirely adapted for use on electric railway circuits, so that if the demand arises, there will be no difficulty met from this direction.

The Evolution of the Electric Railway Motor.

The article in another column by Mr. C. T. Child on the "Evolution of the Electric Railway Motor," will be found of much interest, both to those who took part in the development which he describes, and to the many others who have entered the field after the motor had reached the more uninteresting stage of relative perfection. The difference between the Edison-Field electric car equipment of 1883 and the equipment of to-day is perhaps as great as between the steam engine of the last century and that of a few years ago, if the adaptation to working conditions is considered. Indeed, it is doubtful if the continuous-current electric car equipment of to-day is capable of much further improvement, for in adaptation to the conditions of its work and in efficiency it seems to meet every requirement. It is quite probable, however, that in a few years a new chapter may be added to the story of evolution—one relating to the rise of the polyphased car motor. Indeed, did not the perfection of the continuous current motor render it such a formidable rival, the first pages of that chapter might already have been witten.

◆

Commercial Standardization.

A successful outcome of the movement now on foot under the lead of President Nicholls, of the National Electric Light Association, having in view the adoption as a commercial standard of a single type of socket and lamp base, will be most hearily wished by every one interested in that matter, and particularly by lamp manufacturers and supply dealers. The matter of a standard base and socket for incandescent lamps has long been before the electrical public, but until President Nicholls took hold, the subject, had remained in the plane of discussion or, at most, merely led to the appointment of committees which either never reported or whose reports were followed by no action. It is true that up to within a few years the rivalry of "systems" would have led to strong opposition to the adoption of a standard, but at almost any time during the past two years the matter has been ripe for the executive action only now taken.

The sense of those present at the recent meeting which considered the subject, was that the Edison type of base and socket is best adapted for a standard, and in this opinion, we believe electricians will generally coincide. Even those who think differently will realize that any advantage they may consider is possessed by another type, cannot be sufficient to justify opposition which might unfavorably affect the present movement, for the great object in view is standardization, to which other considerations should be subordinated if not of vital importance. One point might be considered before final action, and that is with relation to the safety of the type adopted for use on alternating current circuits. Several cases are on record where death was caused from shock received from a lamp on a grounded alternating circuit. The danger from this source could be minimized by specifying that, if the Edison type of socket and base is adopted, no part of the base shall extend outside the socket.

Another movement in the direction of commercial standardization which is in a fair way toward a satisfactory conclusion, is the promulgation of a standard practical method of photometric measurement of incandescent lamps. A programme which, it is believed, will be satisfactory from both the scientific and commercial standpoints has been prepared, final action being deferred until after its provisions have been examined and criticised by those whom they most affect or interest. The main points thus far decided upon are a sub-primary standard of light, a standard screen, and a method for obtaining comparative photometric measurements with filaments of different shape.

◆

Steam Engines for Electrical Generation.

The manner in which advancement in one art powerfully influences allied ones is well illustrated in the case of the steam engine. With the commencement of electric lighting there was but one type of engine suitable for operating fast-running machines such as the dynamo, and for electrical generation this but crudely answered the requirement of close regulation. In a very short time, however, several machines with improved features were on the market, and for several years following Europe had to look to the United States for its supply of automatic electric light engines. At the present day there are a dozen or more automatic fast-running engines on the market in this country, any one of which a dozen years ago would have been regarded as a prodigy.

The case was similar with respect to engines for electric railway service. The requirements here were even more exacting than in the case of electric lighting. The rapid fluctuations of load and occasional grounds led to strains of which the thought might well appall the manufacturer called upon to put his engine to test. In rolling mill work, it is true, the conditions were somewhat similar, but here the crudest type of engine was sufficient, while the electric railway engineer aspired to but little less than Corliss economy and regulation. How well the situation thus presented has been met by our engine builders, may be determined by a reading of the article in another column on "Steam Engines for Electric Railway Service," in which are illustrated and described the principal types made in this country. It has been only within the last several years that the greatest improvements have been made—that direct connecting has become the rule, and compound and even triple expansion have ceased to be looked upon as heresies in electric railway work. Yet in no respect do the types give indication in design or operation of the rapid process by which they have arrived at their present state.

There are yet, however, a number of questions concerning engine design and economy which are left in an uncertain state. Notwithstanding the success that has attended the use of compound engines working under conditions of widely varying loads, many continue to insist that under such conditions the compound engine is wasteful, and still more strongly believe in the disqualification of the triple expansion engine for such service. In the light of the investigations of Durand, Carpenter, Kennedy and others, showing this view to be incorrect, at least within the usual limits of practice in electrical generation, such a belief can be regarded little otherwise than as a prejudice—perhaps descended from the days when the battle between simple and multiple expansion raged so furiously. The adoption in many cases of a reheater between cylinders in which different stages of expansion are carried on, is a promising advance, for its logical outcome is superheating of the steam in the first instance. It is from this direction that the greatest improvement in steam working is to come, and the reheater of the engine builder is leading the way.

◆

What is Electricity?

Dr. John Trowbridge, in a recently published book with the above title, examines, in some three hundred pages, all of the considerations upon which a reply to the title question should be based, and concludes with the following paragraph—the sole result of his labors: "What shall we, therefore, answer to the question, "What is Electricity? Must we reply, *Ignoramus ignorabimus*—(We are ignorant, and shall remain ignorant)? We have already strong grounds for believing that we live in a medium which conveys to-and-fro or periodic movements to us from the sun, and that these movements are electromagnetic, and that all the transformations of light and heat, and indeed the phenomena of life, are due to the electrical energy which comes to us across the vacuum which exists between us and the sun—a vacuum which is pervaded by the ether, and which is a fit medium for the transmission of the electromagnetic waves."

While this answer is very far from satisfactory, it is yet vastly more definite than could be given in reply to the question, "What is gravitation?" Maxwell, after an examination of all the theories which have been brought forward to explain gravitation, concluded that none of them is valid. On the other hand, at least, the wave theory of the transmission of electricity, and the relation of electricity to light and heat, are established. It is to be regretted that Dr. Trowbridge introduced the phrase, "the phenomena of life," without exact qualification as to what it may mean. We are aware of no grounds upon which such a startling assertion can be based, and fear that it will be seized upon by quacks and charlatans to bolster up their claims, and, moreover, will tend to still further deepen the air of mystery with which electricity is surrounded, and which it should have been one of the objects of the book to dispel.

In glaring contrast to the caution of Dr. Trowbridge is the following answer to the same question, which we clip from an exchange. The writer is apparently of those who look upon the conservatism of the scientific man, as an evidence of intellectual timidity, and who are admirers of people who "speak out" and are not afraid to place themselves "on record." "Electricity," he says, "is a resultant of magnetism; it is caused by magnetism seeking an equilibrium, or rather by seeking to restore an equilibrium. A fac-simile may be produced or imagined by a ship passing through the water, or a bird passing through the air, In each instance the equilibrium is disturbed; and if it were not for the power which is known as gravity (which is an identical parallel to magnetism) a hole would be left where the ship or the bird passed through; but the effort which gravity has been making to fill up that hole has produced something else. In the case of the bird it has produced wind; in the case of the ship it is tide; and in both instances it is power which has been produced. And so it is with magnetism. If it is withdrawn or absorbed or concentrated, there is a vacuous situation formed which has to be filled up; the accomplishing of which requires power and the production of that power is what we know as electromagnetism (*elected* to fill a vacancy); and in filling that vacancy friction has been incurred, and friction produces electricity or heat, either of which is power which can be concentrated by mechanical appliances."

THE CONSTRUCTION OF A BUNSEN PHOTOMETER FOR STUDENT USE,

BY PROF. A. F. MCKISSICK.

The writer having need of a reliable and inexpensive photometer for student use, devised and constructed the following apparatus, which has proved very efficient.

The bar was made of a piece of pine board surfaced up, 17 ft. long, 6 ins. wide and 2 ins. thick, with two strips each 2 ins. × 1 in., nailed on its upper surface, thus forming a groove 2 ins. wide and 1 in. deep, the whole length of the board, as shown in Figs. 1 and 2.

One of these strips was graduated near its outer edge in centimetres for a length of 500 centimetres, thus leaving a space of about four inches at each end. These graduations were inked and numbered and the bar then supported firmly in a horizontal position.

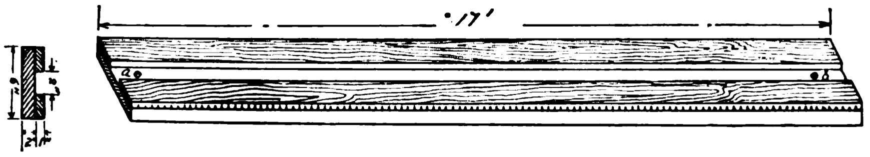

FIG. 1.—PHOTOMETER BAR.

At *a* and *b*, the beginning and ending of the graduation, lamp sockets were fastened to the board. One of these sockets was arranged so as to be rotated, and a pointer attached to the socket enabled different readings to be made for different angles as indicated by the pointer on a paper circular scale attached to the board. The other socket could also be rotated, but did not have the pointer and scale.

For a standard source of light an incandescent lamp whose candle power has been accurately determined is used. The General Electric Company furnished some lamps, calibrated accurately, giving the candle power of the lamp in a certain position.

The photometer box or carriage was made of white pine 5 × 5 × 5 ins., as shown in Figs. 3 and 4. On the bottom of the box was screwed a strip, *j*, two inches wide and one inch deep. This strip fitted into the groove of the bar, and the box could thus be easily shifted to any position of the bar. A hole, *i*, about 3 ins. in diameter was cut in two opposite sides of the box and another in the top, where the eye pieces were fitted. The eye pieces consisted of two cylinders of zinc one inch diameter, soldered to a square piece of zinc, and also fastened rigidly together by a bridge, not shown in the sketch. This base piece was then tacked to the box.

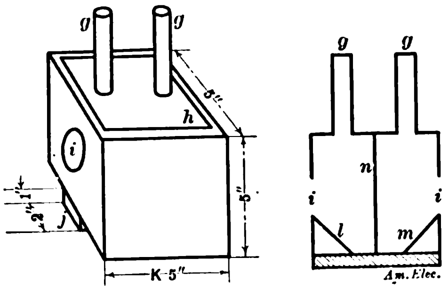

FIG. 2.—PHOTOMETER BOX.

The screen, *n*, and the mirrors, *l* and *m*, were so fastened that the light from each side of the "grease spot" on the screen was reflected up the zinc cylinders. The screen consists of a piece of stiff cardboard painted black, with a circular hole cut in its centre. Over this hole is pasted a piece of white paper with a spot on it rendered translucent by a drop of oil or by paraffine. The inside of the box was painted black, a mixture of shellac and lamp black being used.

Before making an experiment each lamp is covered with a small box whose interior has been painted black, and having a hole cut in one side for the passage of the light to the "grease spot."

A pointer, *k*, of thin brass is attached to the photometer box in line with the "grease spot" for taking readings on the graduated bar.

In making a measurement, the photometer box or carriage being placed between the two lights, each face of the screen is illuminated only by light from the source toward which it is turned, while the translucent portion of the paper receives light from both sources. In using the instrument, the carriage is shifted in position until both sides of the screen are seen to be equally illuminated. The distances of the two lights from the screen are then ascertained by observing the position of the pointer, and the relative intensities of the two sources are computed by the law of inverse squares.

By having the wires from the two sockets lead to two different sources whose potentials can be varied, the standard lamp can first be brought to candle power as marked and the candle power of the other lamp then measured for varying voltages and positions.

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Electrical Engineering at the University of Wisconsin.

During the past collegiate year at the University of Wisconsin there were 97 students in the several classes of the electrical engineering course. Fourteen graduates in electrical engineering received the degree of Bachelor of Science, and one that of Electrical Engineer. From the University catalogue we learn that the electrical laboratory is well supplied with exact scientific and commercial instruments, and arranged for both instruction and investigation. The equipment is unusually complete in the lines of continuous current, and single and polyphase alternating current generation and distribution, and commercial electrochemistry. The dynamos in the laboratory are arranged in a large special room, with a special engine of exceedingly close speed regulation. For use in testing dynamos, all necessary apparatus, including a Brackett cradle dynamometer is at hand. A photometer room is well arranged for the commercial comparisons of arc and incandescent lamps, or for scientific investigations. Prof. D. C. Jackson has charge of the course with Assistant Prof. S. B. Fortenbaugh, Mr. Burgess and Mr. Ford, as assistants.

FAULTS AND HOW TO FIND THEM.

RHEOSTATS AND ARC REGULATORS.

A fault is often ascribed to a dynamo when it really exists in some of the controlling or regulating devices. This section will discuss such faults.

The ordinary rheostat is liable to contain a fault, and in the absence of other causes of a trouble such a defect should be sought for. The rheostat may be either short-circuited, open-circuited or grounded. A short-circuited rheostat fails to regulate the voltage when the handle is turned over the contacts, and the voltage of the machine becomes at times higher than it should be. If there is a considerable margin for regulation in the rheostat, the voltage in the case just cited may be high enough to burn out all the lamps in circuit, or perhaps to "motor" the machines running in multiple with it. This is a serious emergency and the faulty machine should be switched out at once. Adjustment of the difficulty may then be made at leisure.

If a portion of the rheostat is short-circuited, it will refuse to regulate through a portion only of its range. The short circuit is generally pretty obvious when the rheostat is taken apart. In a coil rheostat, the adjacent coils may have been overheated and lost their spring, the coils thus drooping and making contact. An enamel rheostat cannot be repaired unless the difficulty is external. It should be sent to its manufacturers, but it is only fair to state that enamel rheostats are little likely to get out of order.

A short circuit in a motor-starting rheostat is evidenced by a sudden burst of speed as the rheostat is turned on. If the rheostat is completely short-circuited, the fuse will probably be blown upon throwing of the main switch, and the motor will make a spasmodic and powerful start, sparking furiously at the brushes as it does so, but quickly ceasing to turn as the fuse blows.

Open circuit in a field rheostat is accompanied by refusal to excite. In a motor-starting rheostat, the motor will refuse to start till after the arm has swung past the open-circuited position, when it will start with a powerful jerk. This in itself indicates that the open circuit lies between the button on which the motor started and that just adjacent. However, it is better to use a magneto in testing for the fault, provided that the position at which the motor started was not noted. Connect one terminal of the magneto to the binding post of the rheostat and after disconnecting the other wires, run the other terminal of the magneto over the contacts. As the terminal advances a contact will be found where the bell begins to ring and between this contact and the one just passed is the open circuit. This applies to any type of multiple-contact rheostat. If there are several open circuits, they may be found and connected one by one by this method.

The regulators of constant-current dynamos are often harborers of faults, and in case of poor regulation trouble may always be suspected there, although poor regulation is not positively conclusive evidence of a poor regulator.

One of the best known regulators is the Brush dial. This regulator consists of a magnet in series with the main circuit, which draws up a core and compresses piles of carbon wafers. The resistance of this pile of wafers varies as it is compressed, and this variable resistance is placed in multiple with the field, deflecting more or less current therefrom. A cut of the governor is shown in Fig. 1. There are several carbon piles in series with one another, packed in little troughs and covered with the slate slab, *KK*. The terminals of this part of the circuit are the two small binding posts at the upper part of the case. The compressor magnet, *MM*, pulls up the lever, *L*, and squeezes the carbon piles. In series with the main circuit is another magnet whose function is to open a pair of contacts when the current gets too strong, and allow them to close by spring tension if it becomes too weak. These contacts are in a circuit of resistance which is connected in multiple with the compressor magnets. This resistance is wound on two slate rods, *W*, and the spring, *S*, varies its amount. The tension of the contacts is varied by the nut, *N*, and the contacts themselves are shown at *C*. A dash pot, *P*, prevents sudden motions of the mechanism.

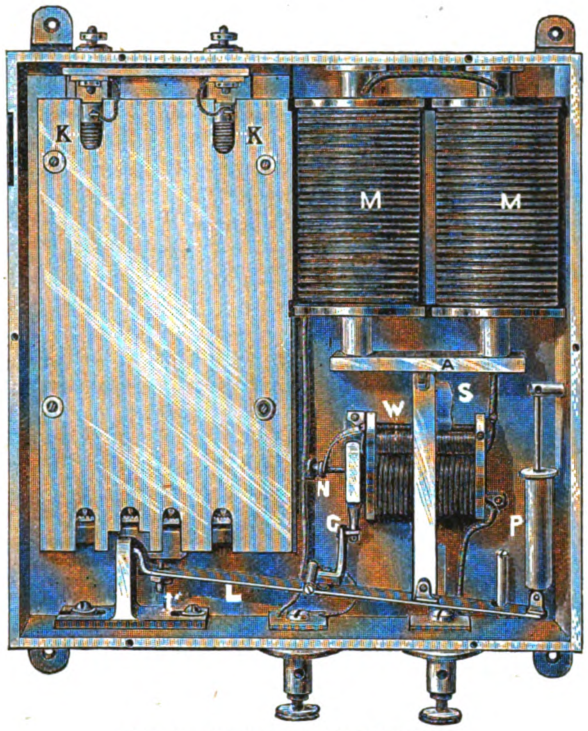

FIG. 1.—BRUSH ARC REGULATOR.

The most frequent trouble with a Brush dial is the oxidation of the contacts, *C*. Brightening them with crocus cloth and readjusting the nut, *M*, will usually remedy any difficulty that may arise. If the governor should fail to respond when the current is abnormally great, see that the contact, *C*, is open. If this is the case, see if the mechanism has not stuck somewhere and is thus irresponsive to the pull of the compressor magnet. If the lever still fails to rise, it is probable that the compressor magnet is wholly or partly short-circuited.

If the current is too weak and the regulalar fails to respond see that the regulator arm is down as far as it will go. If this is the case, take hold of the wires at the terminals of the carbon piles and make sure that the lumps of carbon to which they are attached *are loose* and simply rest on the top of the piles of carbon. If these prove to be as just stated, the probability is that the dynamo is overloaded.

It is barely possible that the carbon piles have become short-circuited, or that the terminals of the machine fields are spanned by some resistance which deflects current therefrom and cuts down the magnetism. The current can often be brought up to its proper value by cleaning the commutator segments with sandpaper. The writer has seen machines reduced in output one hundred volts by a dirty commutator.

If the regulating arm draws up tightly and refuses to relax when the current falls below the normal value, see that the contact, *C*, is closed and the contact points are clean. If the regulator still refuses to act, reduce the resistance, *W*, by the spring clip, *S*. Should the current fail to reduce to the normal value with the machine on short circuit, tighten the screw, *I*, thus squeezing the carbon piles nearer together. When the dial is working properly, the contact, *C*, is sparking all the time.

The Thomson-Houston wall controller is simply a part (the small magnet) of the Brush regulator in its principle. It is shown in diagram in Fig. 2. The large magnet, instead of shunting the field, *shifts the brushes* in their angular position on the commutator, and the wall controller simply short circuits that magnet when the current becomes too strong. The resistance, *R*, simply reduces the sparking at *S* and *T*. The armature of the Thomson-Houston wall controller, being very much heavier than the armature of the contact magnet, opens and closes the short circuit on its operating magnet less frequently. It picks up its armature and drops it about once per second, and the brushes on the commutator oscillate back and forth in perfect step.

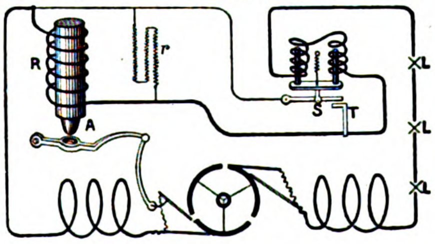

FIG. 2.—T.-H. ARC REGULATOR.

The faults that are liable to occur in the Thomson-Houston controller are very similar to those that may occur with the Brush dial. Short circuiting of the operating magnet will produce a current that is too heavy, and in such an event the wall controller contact should be always open. Similarly, if the current is too light, the wall controller circuit should be closed. If the controller circuit is closed and the current is still too light, see that the contact points are clean. If the light wire connecting *S* with the large magnet be broken, the current will be too great and the controller will cease to have contact.

Always look for the mechanical difficulty and be sure that the lever does not stick. In fact, all of the instructions given for the Brush dial may be applied to the Thomson-Houston controller, assuming that the Thomson-Houston brush adjusting magnet and the Brush compressor magnet are the same as regards treatment for faults, and that the wall controller magnet and the little relay magnet have a similar likeness. Of course, in the Thomson-Houston controller, adjustment of the resistance and pressure of the carbon piles do not enter.

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AMERICAN TELEPHONE PRACTICE.

HISTORY AND PRINCIPLES OF THE MAGNETO TELEPHONE.

BY KEMPSTER B. MILLER.

The history of the telephone from its inception to its present state of perfection, is interesting in the extreme, and affords a striking example of the fact that great inventions are almost invariably the result of long and careful study on the part of many workers, rather than the sudden inspiration of a single genius. It is of even greater interest from a scientific standpoint, for in no way can one obtain a better idea of the fundamental principles involved in telephony than by following their development, step by step, noting the contributions made by each of the many scientists and inventors whose names are closely connected with the art.

These steps were made in logical order, the knowledge contributed by each investigator making possible a deeper insight into the subject on the part of his successors. It is best, therefore, to follow this order in obtaining primary ideas of the subject.

The history of the knowledge of electromagnetism begins in 1819, and with this date very properly begins the history of the electric telephone. In this year Oersted, a professor in the University of Copenhagen, discovered that a magnetic needle tends to place itself at right angles to a wire carrying a current of electricity. He further developed the laws regarding the deflections corresponding to the directions of the current in the wire, and those corresponding to the positions of the wire with respect to the needle.

In the following year Arego and Davy discovered that if a current be caused to flow through an insulated wire wrapped about a a rod of steel the latter would exhibit magnetic properties. It was William Sturgeon, however, who in 1825 made an electro-magnet as we know it to-day, and called it by that name. To Sturgeon, therefore, belongs the credit of one of the greatest discoveries in the history of science. Joseph Henry also made his classic experiments on the electro-magnet, and to him must be accredited a large amount of our knowledge regarding it. Henry showed how to build a magnet capable of being operated over a great length of wire, a most important step.

In 1831 Faraday and Henry, independently discovered the converse of these laws of electromagnetism—that if the intensity of a magnetic field enclosed by a conductor be in any wise changed, a current of electricity will flow in said conductor. This current will flow only while such change is taking place, and its strength will depend directly on the rate of the change.

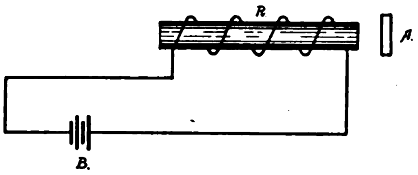


FIG. 1.—STURGEON—ELECTROMAGNET.

These two laws concerning the transformation of electric energy into magnetic, and its converse, the transformation of magnetic energy into electric, are certainly the most important in the whole realm of electrical science, as singly or together they form the foundations not only of the telephone and telegraph, but of electric lighting, electric power transmission, and of every other achievement by which electricity has revolutionized the methods of life throughout the whole civilized world.

As these laws form the very root of all telephone practice, a few illustrations directly in line with the principles of the telephone will not be amiss, even though they are very generally understood; for they will give a clearer understanding of the developments made by subsequent inventors. If, as shown in Fig. 1, a coil of wire be wrapped around a rod, *R*, of iron or steel, and a battery, *B*, placed in circuit with the coil, the rod becomes a magnet upon the closure of this circuit, and will attract an iron armature, *A*, in the vicinity of either of its poles. Any variation in the strength of this current will cause corresponding variations in the attractive power of the magnet. If the rod be of steel, and permanently magnetized, it will exert an attractive force of its own on the armature, and the current will, according to its direction, increase or diminish this attractive force.

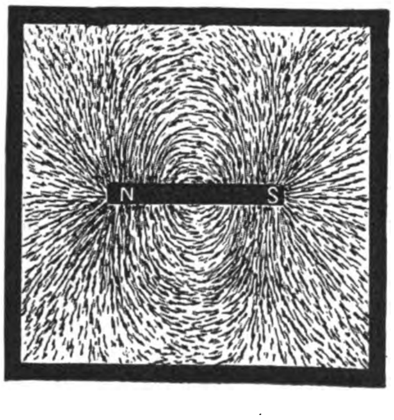


FIG. 2.—LINES OF FORCE OF BAR MAGNET.

About every magnet there exists a field of force; that is, a region in which any body capable of being magnetized (such as iron), has exerted on it, by the magnet, an influence of attraction or repulsion. This field of force is usually graphically represented by closed curves, radiating from the poles of the magnet, as shown in Fig. 2, and the strength of the magnet is commonly measured in terms of the number of such lines radiating from one of its poles. If now a galvanometer, *G*, or other current-indicator (Fig. 3) be placed in circuit with a coil, *C*, and a magnet, *NS*, moved in the vicinity of the coil, or the coil in the vicinity of the magnet, in such manner as to change the number of lines of force passing through the coil, a current is generated in the coil and is indicated by the galvanometer. This current will flow only while the magnet is being so moved. Its direction will depend on the direction of the lines of force threading the coil and on whether their number is being increased or diminished. Its strength will depend on the rate at which their number is changing.

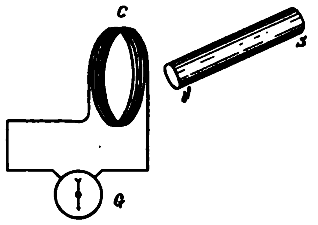


FIG. 3.—FARADAY AND HENRY—MAGNETO ELECTRICITY.

If a mass of iron be brought within the field of a magnet, the field becomes distorted by virtue of a larger number of lines finding their path through the space occupied by the iron than through the same space when filled with air. Therefore, if a closed coil be placed about a pole of the magnet and a body of iron be moved to and from the pole, the intensity of the field in which the coil lies will vary, and currents of electricity will flow in the coil.

In 1837 Prof. Page, of Salem, Mass., discovered that a rod of iron, suddenly magnetized or demagnetized would emit certain sounds due to a molecular rearrangement caused by the changing magnetic conditions. This phenomenon is known as "Page's effect."

Late in the Thirties, Prof. S. F. B. Morse placed at one end of a line Sturgeon's electro-magnet, *M* (Fig. 4), with a pivoted armature, *A*, and at the other end a battery, *B*, and a key, *K*, for making and breaking the circuit. By manually closing and opening the key the core of the magnet became magnetized and demagnetized, thus alternately attracting and releasing the armature. By this means signals were sent and recorded on a strip of paper, carried on a roller, *R*, in front of the armature, and thus for the first time intelligence was electrically conveyed between distant points.

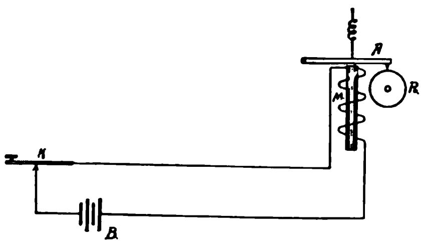


FIG. 4.—MORSE—ELECTROMAGNETIC TELEGRAPH.

In 1854 a Frenchman, Chas. Bourseul, predicted the transmission of speech, and outlined a method correct save in one particular, but for which error one following his directions could have produced a telephone of greater efficiency than that subsequently devised by Bell. His words at this date seem almost prophetic: "Suppose a man speaks near a movable disk sufficiently flexible to lose none of the vibrations of the voice, and that this disk alternately *makes and breaks* the current from a battery; you may have at a distance another disk which will simultaneously execute the same vibrations."

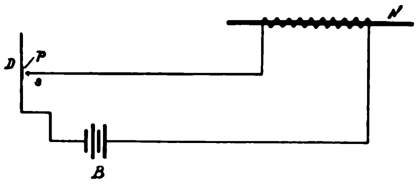


FIG. 5.—REIS—MAKE-AND-BREAK TELEPHONE.

Philip Reis, a German inventor, constructed a telephone in 1861, following very closely the path outlined by Bourseul. He mounted a flexible diaphragm, *D* (Fig. 5), over an opening in a wooden box, and on the center of the diaphragm fastened a small piece of platinum, *P*. Near this he mounted a heavy brass spring, *S*, with which the platinum alternately *made and broke* contact when the diaphragm was caused to vibrate. These contact points formed the terminals of a circuit containing a battery, *B*, and the receiving instrument. His receiver assumed various forms, prominent among which was a knitting needle, *N*, wrapped with silk-insulated copper wire and mounted on a cigar box for a sounding board. Its operation was as follows: The sound waves set up by the voice struck against the diaphragm of the transmitter, causing it to vibrate in unison herewith. This made and broke the circuit at the contact points, and allowed intermittent currents to flow through the receiver. These currents, which exactly synchronized with the sound waves, caused a series of sounds in the knitting needle by virtue of "Page's effect." The sounding board vibrated in unison with the molecular vibrations of the needle, and the sound was thus greatly amplified.

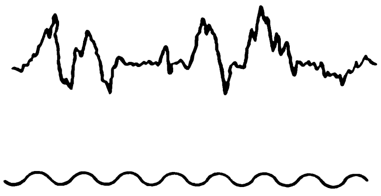


FIG. 6.—SOUND WAVES OF VOICE AND OF SIMPLE MUSICAL NOTE.

Reis's telephone could be depended upon to transmit only musical sounds, but it is probable that it did actually transmit articulate speech. The cause of this partial failure will be understood from the following facts: A simple musical tone is caused by vibrations of very simple form, while sound waves produced by the voice are very complex in their nature. These two forms of waves are shown graphically in Fig. 6. Sound possesses three qualities: pitch, depending entirely on the frequency of the vibrations;

loudness, depending on the amplitude of the vibrations, and timbre or quality, depending on the form of the vibrations. The tones of a flute and a violin may be the same as to pitch and loudness and yet be radically different. This difference is in timbre or quality.

Reis's transmitter was able only to make and break the circuit, and a movement of the diaphragm barely sufficient to break the circuit produced the same effect as a much greater movement. The current therefore flowed with full strength until the circuit was broken, when it stopped entirely. The intermediate strengths needed for reproducing the delicate modulations of the voice were entirely wanting. This apparatus could therefore exactly reproduce the pitch of a sound, but not its timbre and relative loudness.

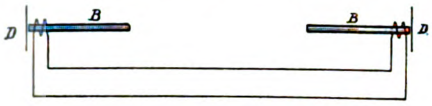


FIG. 7.—BELL—MAGNETO TELEPHONE.

For the next fifteen years no great advance was made in the art of telephony, although many inventors gave it their careful attention.

In 1876, Prof. Alexander Graham Bell and Prof. Elisha Gray almost simultaneously invented successful speaking telephones. Although Bell has reaped the profit, the U. S. Patent Office having awarded priority of invention to him, an equal share of the honor is due to Gray.

Bell possessed a greater knowledge of acoustics than of electrical science, and it was probably this that led him to appreciate wherein others had failed. His instrument consisted of a permanent bar-magnet, *B* (Fig. 7), having on one end a coil of fine wire. In front of the pole carrying the coil a thin diaphragm, *D*, of soft iron was so mounted as to allow its free vibration close to the pole. Two of these instruments are shown connected in a circuit in Fig. 7.

Two points will be noticed which have heretofore been absent: That no battery is used in the circuit, and that the transmitting and receiving instruments are exactly alike. When the soft iron diaphragm of the transmitting instrument is spoken to it vibrates in exact accordance with the sound waves striking against it. The movement of the diaphragm causes changes in the magnetic field in which lies the coil, which changes, as shown above, cause an alternating current to flow in the circuit. This current varies in unison with the movements of the diaphragm. The waves of this current are very complex, and represented graphically are similar to those of the voice shown in Fig. 6. Passing along the line wire, these electrical impulses, so feeble that only the most delicate instruments can detect them, alternately increase and decrease the strength of the permanent magnet of the receiving instrument, and thereby cause it to exert a varying pull on its soft-iron diaphragm, which, as a result, takes up the vibrations and reproduces the sound faithfully.

Bell's form of instrument, with a few minor changes, is the standard of to-day. It is now used as a receiver only, a more efficient transmitter, depending upon entirely different principles, having been invented.

In concluding this sketch, Lord Kelvin's words seem appropriate: "Who can but admire the hardihood of invention which devised such very slight means to realize the mathematical conception that if electricity is to convey all the delicacies of quality which distinguish articulate speech, the strength of its current must vary continuously as nearly as may be in simple proportion to the velocity of a particle of air engaged in constituting the sound?"

* * *

Repair of Electric Railway Apparatus.

BY W. E. SHEPARD.

The Walker Motor.

The Walker motor has been before the public now about three years. It is the youngest in point of history of those which we have been considering, and yet contains many features of a decidedly superior design. The motor is of the four-pole, salient, cross-connected design, somewhat similar to the Westinghouse and to the more recent design of General Electric, type 1000.

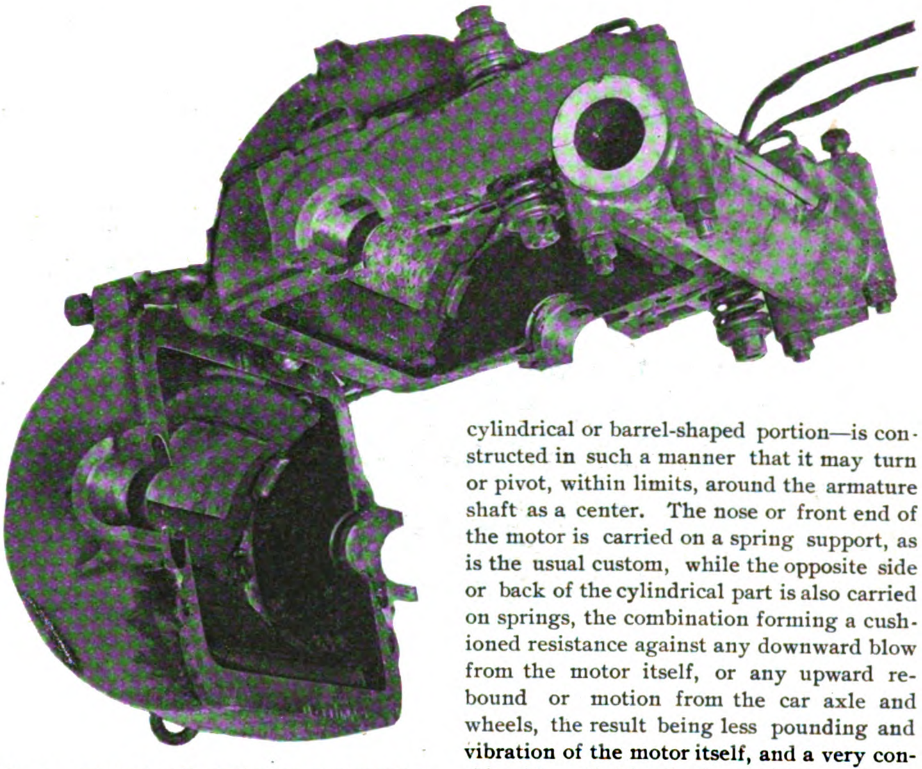


FIG. 1.—WALKER STREET RAILWAY MOTOR.

The arrangement of the poles together with energising field-coils is clearly shown in Fig. 1. The wires leading to the field coils are shown above to the right. Current comes in on one, passes through the two coils in the upper half of the frame, thence down through the two coils in the lower half, and, returning above, passes out through the second wire, all four of the coils being connected in series with the armature in the usual way.

As is seen in Fig. 5, the motor is completely iron-clad. There is no possibility of water entering the interior unless the motor is run in water up to the height of the armature bearings, nor is there any possibility of water or spray, which may be splashed from the wheels, trickling in through the bearing caps or other crevices in the frame. These motors have been operated by the writer, forty-eight consecutive hours through fine driving snow followed by rain and slush, and on opening for the purpose of ascertaining whether there might be any dampness or leakage, the cases were found to be absolutely dry. In the opinion of the writer the water-proof features of this motor are all that can be desired.

It will be noticed in Fig. 1, that the main bearings of the motor through which the car-axle passes, are connected across by a hollow casing on a sleeve. This prevents the collection of sand and grit in the bearings, and increases their life by more than double the life where exposed.

A peculiar feature of this motor, and one which is of the greatest possible value in the long run of continued maintenance expense, is the method of supporting the bulk of the weight of the motor on compression springs, rather than letting it rest as a dead weight upon the car-axle. The motor proper—the cylindrical or barrel-shaped portion—is constructed in such a manner that it may turn or pivot, within limits, around the armature shaft as a center. The nose or front end of the motor is carried on a spring support, as is the usual custom, while the opposite side or back of the cylindrical part is also carried on springs, the combination forming a cushioned resistance against any downward blow from the motor itself, or any upward rebound or motion from the car axle and wheels, the result being less pounding and vibration of the motor itself, and a very considerable relief in the force of the blow on the rail consequent upon poor alignment and imperfect jointing.

Another very important and valuable feature is shown in Fig. 4. This will be seen to represent a cross section of the motor through the center of the bearings. A soft mineral grease is ordinarily used as lubricant for these bearings, which is fed into them by means of gravity only. Whatever of grease is used must pass through the bearings and find vent somewhere. Unless, now, some efficient means is provided to carry off this waste and dirty material, it will inevitably collect on the armature shaft, commutator and body of the armature, which, after a short time, will become so considerable that it is thrown off in the interior of the motor on to the brush-holders, field-coils and sides of the motor, thus causing much damage as well as inconvenience.

Fig. 4 shows clearly the method adopted

in this motor for providing against such trouble, which, in some types of motors is very serious. At the point where the shaft of the armature passes through the body of the motor, the frame is extended outward, forming a large hollow pocket exterior to the motor. In the center of this pocket a large metallic disk is securely fastened to the shaft, and rotates with it. This device is seen at *C*, Fig. 4, and in Fig. 1. The waste grease and oil, working out through the bearing, comes against the face of this disk, which, on account of its rapid rotation with the armature, throws the greasy substances outward by centrifugal force against the walls of the pocket, to which it clings, and, being warm from the operation of the motor readily runs down through an opening at the under side and drops outside the motor to the ground.

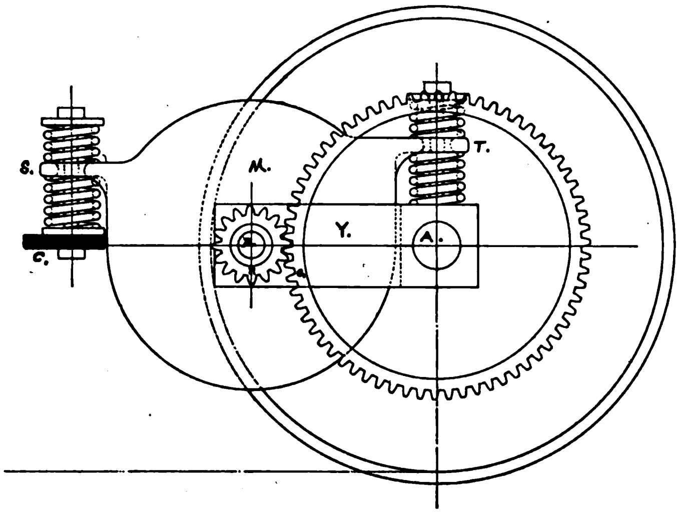


FIG. 2.—SUSPENSION OF WALKER MOTOR.

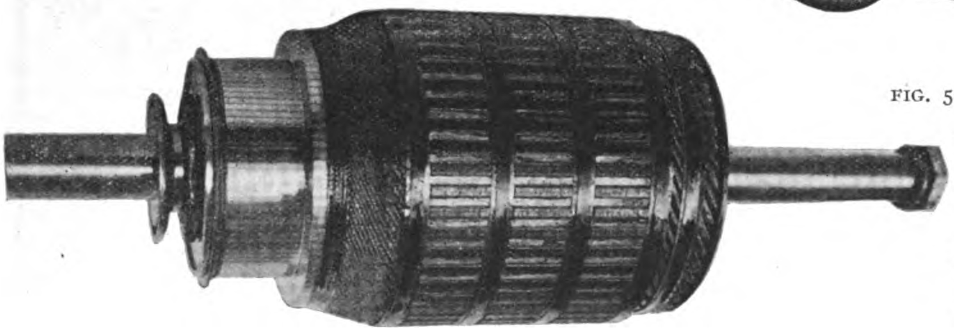


FIG. 3.—ARMATURE OF WALKER MOTOR.

Where such oil-ring or grease-throwing device is not used, as is the case in some motors, this same objectionable matter must inevitably reach the interior of the motor and be thrown off by the commutator at the one end and by the head of the armature at the other, tending to produce a rapid breaking down of insulation and injury to the motor. Too much stress cannot be placed upon the necessity of such an arrangement, which, as applied to this particular motor, accomplishes all that may be desired.

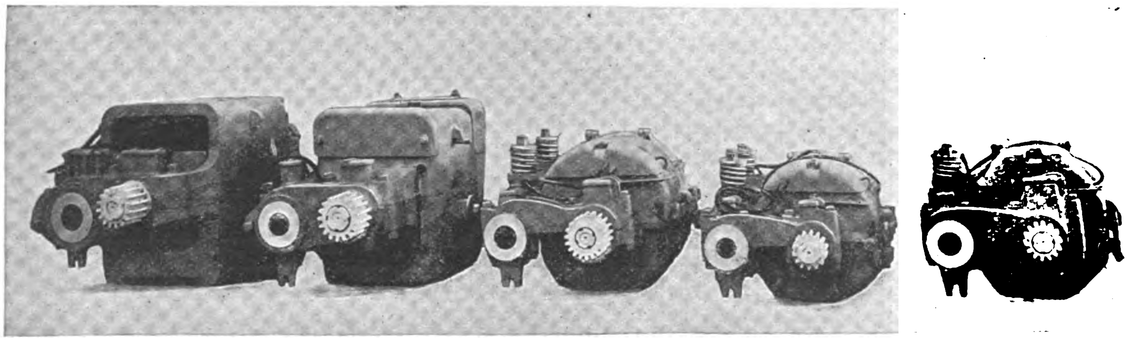


FIG. 6.—TYPES OF WALKER MOTORS—125, 75, 50, 35 AND 25 HP.

The bearings of the Walker motor are ample in their dimensions, of the usual cast-iron shell, with babbitt lining pattern, fed by grease pockets above by gravity.

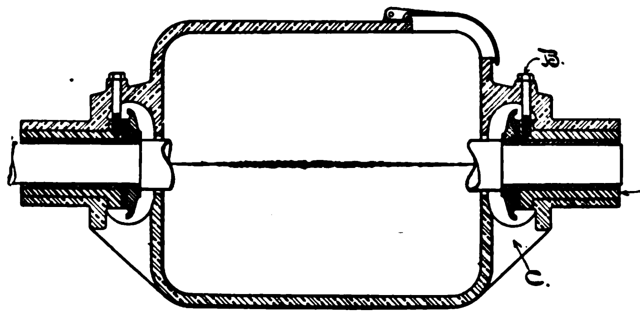


FIG. 4.—CASE AND BEARINGS OF WALKER MOTOR.

The armature is shown in Fig. 3. In proportion and exterior finish it is quite similar to the Westinghouse, but in winding, placing of coils and connecting is nearer the General Electric. It is slot-wound, with 190 independent coils, ninety-five sections in the commutator, and often, in completing, the body is covered with a heavy water-proof insulating wrapping over which the bands are laid on.

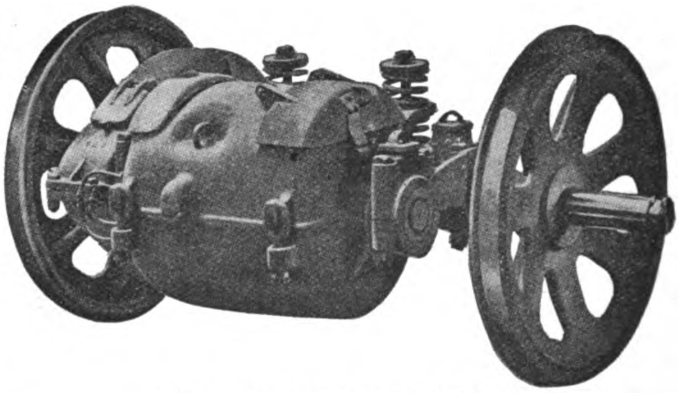


FIG. 5.—WALKER MOTOR MOUNTED.

This method of construction of armature has at least one advantage and at least one disadvantage. In the General Electric armature the iron of the core projects out beyond the windings and their insulation, and the bands are sunken below the surface of these strips of bare iron core so that the "clearance" of the armature is also the "gap." Where the iron core and windings are, after completion, covered by an insulating wrapping, as in the Walker and Westinghouse armatures, in order to insure the same amount of clearance between the rotating armature and the pole-faces of the fields, there must of necessity be a greater "gap." This magnetic "gap" must be increased by whatever the amount of thickness of this insulation multiplied by two. The result of this is, all other factors remaining the same, the necessary expenditure of an increased amount of energy in the fields coils in order to produce the same strength of field, or in other words, all other factors being the same, a more or less lower efficiency.

On the other hand, bearings will wear out; they will sometimes melt out and, the greatest care and attention notwithstanding, will, from time to time, strike against the projecting pole-faces. When this happens in an armature where iron-to-iron is the result, intense heating and burning, due to the friction of the rapidly rotating armature, follows. Bits of the narrow teeth in the laminated core are forced over against the armature coils, cutting into and, of course, grinding and burning them. Or again, the bursting or loosening of a band will almost invariably produce the same results.

In the case of an armature having an insulating shell or covering, when either of these accidents occurs, there yet remains between the iron of the field-pieces and the iron of the armature a considerable space, so that, in either case, the burst or worn off bands and insulation are simply ground up between the iron surfaces, resulting in most instances in little or no further damage than the destruction of these bands and the insulating shell, which, of course, is a far less expensive matter to replace than the windings themselves.

INTERIOR WIRING.

SPECIAL COMBINATIONS.

The distribution of current to large groups of lamps such as occur in electric signs or large chandeliers, often calls for some ingenious manipulation of circuits. Take, for instance, a long electric sign with the words ELECTRICAL EXPOSITION. On such a sign it would not be good practice to run a long pair of wires through each letter and branch the lights across them, for not only would the wires be too large to connect into the porcelain receptacles usually employed in such work, but there would be a noticeable difference in the brilliancy of the letters, the letters nearest the source of supply being brighter. Moreover, it is doubtful if any insurance inspector would permit any such work to exist on risks taken by his company.

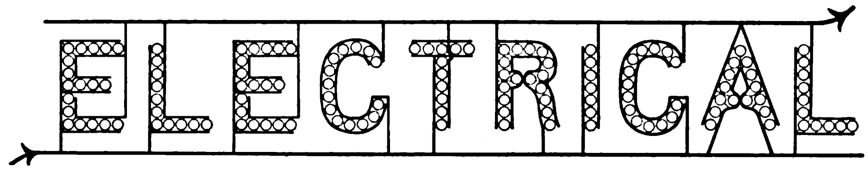


FIG. 1.—ELECTRIC SIGN.

For the above reasons it is common practice to subdivide the circuit, and the most convenient and effective way to accomplish this in the particular case cited is shown in Fig. 1. With this arrangement the letters will be all of equal brilliancy, and the circuits will be sufficiently subdivided to conform to insurance rules. Moreover, the circuit of any letter can be readily opened to insert a controlling switch.

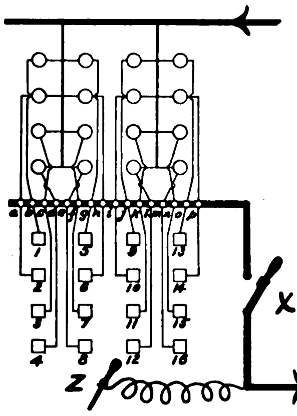


FIG. 2.—MANHATTAN BEACH SIGN.

With large bunches of lights such as are used on signs like the Manhattan Beach sign, it is convenient to wire as shown in Fig. 2. This gives all of the lamps one terminal, the other going to the controlling mechanism. In the figure which illustrates the Manhattan Beach sign wiring, the lettered circles represent the relay mechanism which holds the circuit closed after the plates have been touched by the stylus, *Z*. *X* represents the gang switch that throws all the lamps off for a new combination.

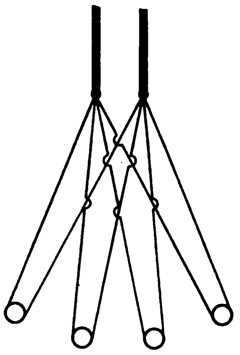


FIG. 3.—CHANDELIER WIRING.

Cluster lights or chandeliers are sometimes troublesome to wire, as there is often but little room inside the fixture. A convenient method that is most often used in simple clusters is to branch the wires as in Fig. 3. The main joints are enclosed in that part of the fixture which forms the common junction of the various branches. Each branch carries a pair of wires running down to the lamp at its end.

Circular chandeliers are common and are more or less troublesome to wire. A most convenient way is to make two complete circles of No. 14 wire as shown in Fig. 4. These rings of wire should be fed with a pair of feeders for every 16 lights if they are 16-CP, 110-volt lamps, or one pair for every 8 lamps if the system is a 55-volt one. This will insure that nowhere in the No. 14 wire will there be more than 10 amperes carried—the insurance rule limit. This enables the use of No. 14 wire whatever the size of the chandelier, a convenience that the wireman will appreciate. The loss is so small with such short wires that it may be disregarded. Of course, the feeders must tap in at equal angular distances from one another, and it is better to feed in the separate wires of each pair of feeders at opposite ends of a diameter, as in Fig. 5. In this way much more uniform distribution is obtained.

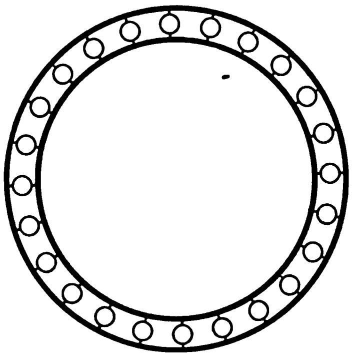


FIG. 4.—CHANDELIER WIRING.

The wiring of cabinets is often quite a problem to do neatly. Combinations of switches and fuses are sometimes required, and more often fuses alone. The circuits may approach the cabinets from the side, the top or the bottom, and the position of the feeders is often equally variable.

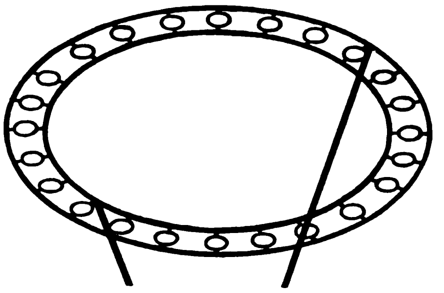


FIG. 5.—METHOD OF FEEDING CHANDELIER CIRCUIT.

When the feeder approaches from the bottom and the circuits leave from the top, the problem is of the simplest. Such a case is shown in Fig. 6. The wires enter the base of the box and turn horizontally, forming a pair of omnibus bars, on which the branch blocks are placed. In the case where some of the circuits go up and some down, the method shown in Fig. 7 may be profitably adopted. It will be noted that the feeder loops around the system of branch blocks. This is not because of drop considerations, but because the full current is not carried by the wires at any one branch block. Branch block contacts as a rule are very poor, and it is well to favor them as much as possible.

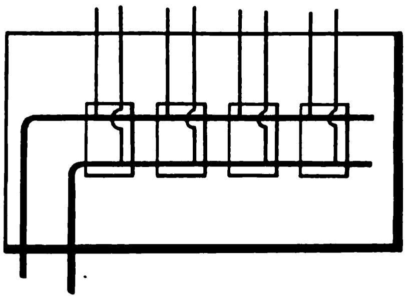


FIG. 6.—CABINET WIRING.

Sometimes a case arises where all of the circuits go up, but are so numerous that two or more rows are necessary. In such a case the wires might be much crowded at the bushings at the top of the box. It is well to so arrange the branch blocks that the positive and negative wires bunch together.

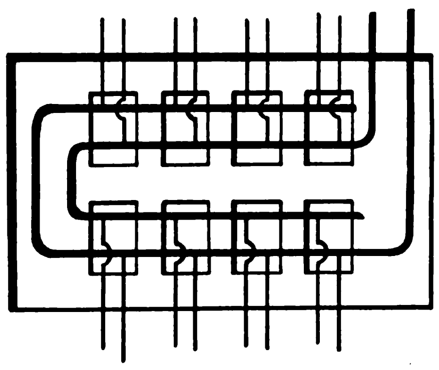


FIG. 7.—CABINET WIRING.

Such an arrangement is shown in Fig. 8. This reduces the number of conductors to be kept apart very materially; if it should be desirable, it would be good practice to run the negative bunch or the positive bunch of wires through the same bushing and even tape those of like polarity together. In switch-board work this will be found to be a most convenient device, for two well insulated conduits will be sufficient to carry any number of circuits with perfect safety.

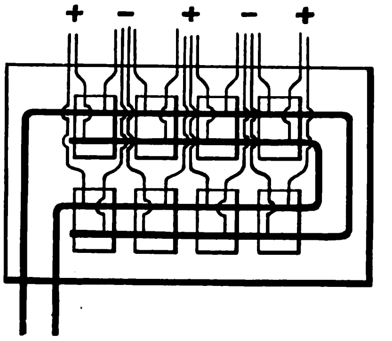
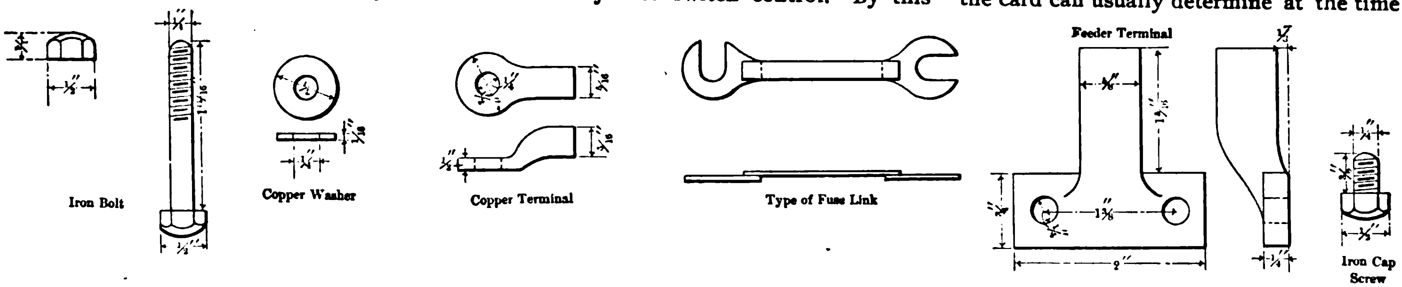


FIG. 8.—CABINET WIRING.



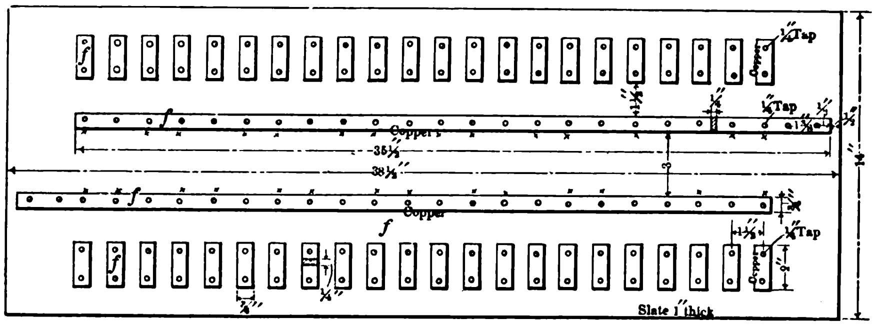


FIG. 10.—SPECIAL CABINET.

Fig. 9 shows a cabinet panel which can have any number of circuits and yet avoids all crosses of circuits of opposite polarity. Fig. 10 is a working drawing of such a panel for 22 circuits. This combination is usually mounted on a piece of slate, and requires to be made to order from drawings. Often the circuits are so numerous that the board would be very long and it would be inconvenient to install it in a vertical position. In such a case, crosses may be avoided by bringing the lower wires back of the switchboard, while the upper wires pass over the front. Such boards are much used where it is desirable to place a number of offices each on a separate circuit.

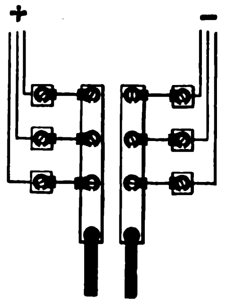


FIG. 9.—PRINCIPLE OF SPECIAL CABINET.

In cabinets containing switches, it is desirable that the fuse block should come first on the circuit, and the switch next. Some of the most serious short circuits are liable to occur within the construction of the switch itself, and unless the circuit is protected back of this point, damage may result. This precaution is not so necessary with single-pole switches, but it is always a good plan to have the fuse as near the source of supply as possible.

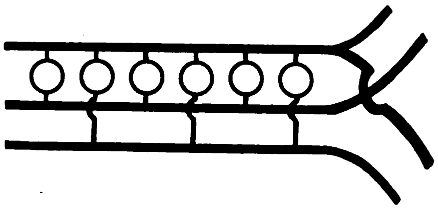


FIG. 11.—ALTERNATE SIGN WIRING.

Alternate wiring has been referred to under the subject of switch control. By this is meant that in combinations of lamps involving long rows, the wiring is so done that every other lamp may be lighted independently of those adjacent. Thus there are two sets of lamps and three combinations: 1, one-half lighted; 2, the other half lighted; 3, all lighted. Only three wires are necessary in such a case, the method being shown in Fig. 11. If there are more than two groups of lamps, the number of wires necessary is one more than the number of groups.

Five hundred volt wiring for lighting purposes is a special combination and can be discussed in a few words here and finally disposed of. In such work the lamps are connected five in series. It is important that the lamps of each set be of the same make, for otherwise they will burn unequally in relative brilliancy. Some will burn too brightly and have a short life and others will scarcely glow and will be extremely wasteful in watts per candle-power. Even lamps of the same maker are liable to thus vary when placed in series.

The whole group of lamps should be considered as a single lamp in calculating the wiring. Thus the lamp feet will be one fifth as much, and the wire will have five times the resistance per foot, other things being equal.

Lamps on 500-volt circuits should be secured in their sockets so that they cannot be readily unscrewed. Key sockets should not be used and every group of lamps should be controlled by a snap switch. The reason for this is because the breaking of such a circuit is accompanied by an arc that burns ordinary sockets badly and ultimately destroys them. Ordinary half-ampere fuse fixtures are not suitable, as 500-volt fuses must be very long in order to avoid any possibility of the arc, following after the fuse is blown.

THE STEAM ENGINE INDICATOR CARD.

Peculiar forms of indicator cards may be classified under two heads—those useful in pointing out effects due to causes likely to normally occur, and "freak" cards, the result of abnormalities that the one taking the card can usually determine at the time, but which, in the absence of engine and other data, become puzzles often scarcely worth the time to solve. Two instances of the latter class are shown in Figs. 6 and 7.

Fig. 1 is a card taken from a 22 in. × 48 in. Corliss engine making 60 r. p. m., the scale being 40 lbs. to the inch, and is as nearly an ideal card as can be obtained from an engine. The steam line, *A B*, is straight and horizontal, while the expansion line, *B C*, coincides almost exactly with the corresponding curve of expansion of a perfect gas. The expansion, it will be seen, is carried down to the very pressure of exhaust, thus utilizing every available portion of work in the steam. The exhaust line, *CD*, is straight and horizontal and the compression line, *DE*, of good shape. As the engine has Corliss valves with little clearance, it is probable that the compression line extends above *E*, for with very small clearance the upper portion of such a curve is so nearly vertical as to actually appear so.

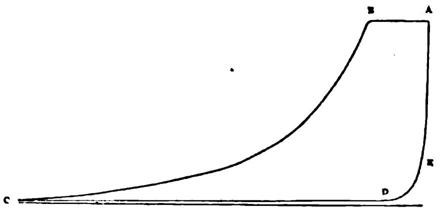


FIG. 1.

Such a card requires almost perfect conditions of steam working—dry steam, small clearance, separate steam and exhaust ports, ports exactly proportioned to piston speed, quick opening and release of steam valve, open exhaust, etc., and it is doubtful if such conditions can be attained in any other engine than of the Corliss type. With the introduction of superheated steam working, which does not seem far in the future, the more usual type of engine will, however, give a radically better card than at present—a card not distorted through the effects of condensation varying from 10 to 50 per cent. with the steam usually supplied.

Fig. 2 is a card from a fast running engine under partial load, and shows the large amount of compression present under such a condition—in this case the exhaust valve closing at about half stroke. It will be seen that in the left hand card the pressure due to compression is carried higher than the initial pressure. Under the circumstances, however, this would scarcely justify any valve readjustment, as the excess of compression would disappear under a larger load and probably not make itself unpleasantly known at the load there indicated. The shape of the end of the compression line may be explained upon the supposition that the excess of compression over initial pressure forced the valve off its seat, thereby causing a drop in the cylinder pressure. The final peak might be due to vibration of the indicator spring, or to a rise again in compression pressure after the valve has reseated.

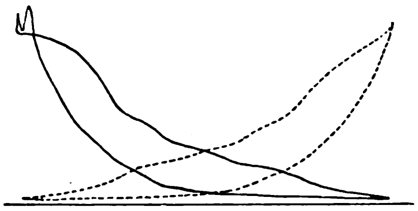


FIG. 2.

Fig, 3 is a card taken from a rolling-mill engine. In this class of work the steam follows full stroke or nearly so, but in the present instance it might be cut off at about three-quarters stroke if there were a free exhaust, and the same power developed with a saving of 25 per cent. The exhaust is much throttled, the cylinder pressure not dropping to the normal exhaust pressure until about half stroke. If the engine was designed to be worked at full stroke, and properly so designed, the cause of the throttling would be looked for beyond the valve.

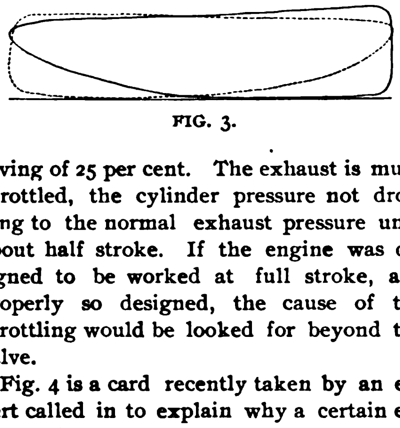


FIG. 3.

Fig. 4 is a card recently taken by an expert called in to explain why a certain engine did not work well. The engine is of the Corliss type, and it is quite evident that the valves were set by guess—the engineer probably being one of those who do not believe in new-fangled ideas and indicators. The steam valve of the left hand card is shown to be properly set, but the exhaust is too late, or does not show a clear opening. The exhaust of the right hand card, on the contrary, is properly set and gives a clear opening, but the steam valve shows a curious condition, not opening until about one-fifth of the return stroke, and then only partially, as shown by the slow rise in admission pressure.

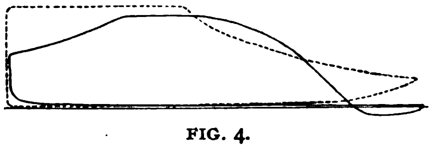


FIG. 4.

Fig 5 is a card taken from a gas engine, and shows the usual high explosion line and quick drop, part of which is due to the inertia of the indicator, and part to the very rapid cooling of the products of combustion by the water jacket. Owing also to the water jacket, there are wide differences in the shape of the expansion lines of cards from different gas engines, or the same gas engine under different loads, due to the loss of heat through the cylinder walls.

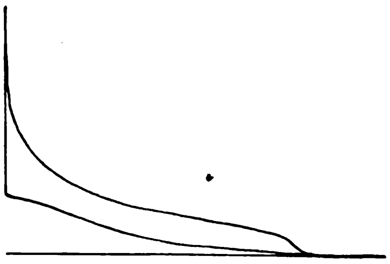


FIG. 5.

Figs. 6 and 7 are "freak" cards, which are offered for explanation to our readers without comment. Fig. 6 was sent to a maker of indicators with a request to explain the cause of the re-entering curve. Fig. 7 is a card taken when the valves of a new engine were being adjusted. Unfortunately both originals were lost before a transcript of data was made, thus making any explanation more difficult to arrive at. It may here be added that in the case of "freak" cards, it is always well to begin with the indicator in attempting to arrive at an explanation, and next to consider whether the aberration may not be due to the manner in which the drum motion is derived—the engine as a cause not being taken up until these points have been disposed of.

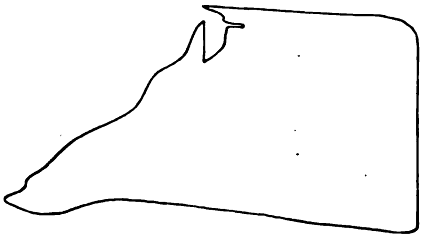


FIG. 6.

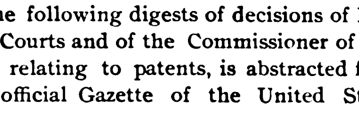


FIG. 7.

RECENT PATENT DECISIONS.

The following digests of decisions of Federal Courts and of the Commissioner of Patents relating to patents, is abstracted from the official Gazette of the United States Patent Office. The publication of this useful information will be continued in our columns from month to month.

In a case decided by the Commissioner of Patents where one S. alone filed an application for a patent for himself and another, as joint inventors, alleging in the oath, petition, and preamble that he and another party are joint inventors of the invention for which a patent was solicited, it was held that an application for a patent for a joint invention must be made by all joint inventors.

The sale of an element of a combination segregated from the whole combination does not break the patentability of the combination.

An assignment of an unpatented invention which does not contain a request that the patent issue to the assignee does not convey a legal title to the patent when granted, but gives only an equitable interest. He who takes such an equitable title, takes it subject to all existing equities, whether he has notice or not.

Although an application for a patent may be considerably confused and informal, yet if the claims, taken in connection with the description and drawing, can be understood, action on the merits should be given.

The Patent Office is not a proper place in which to try an issue as to ownership of a patent. It has no judicial functions for the determination of private rights. The numerous questions pertaining to ownership of an invention or a patent are for the courts to settle. It is not even mandatory on the Commissioner to issue a patent to the assignee of an inventor.

An affidavit which seeks to overcome a foreign patent cited as reference must make a showing of facts that the invention was completed in this country before the date of the foreign patent.

To constitute anticipation of a device, it is enough that such a device has been in well-established use, whether it originated in design or by accident.

Although a device is not commercially perfected and does not do as efficient work as later devices, yet if it shows every feature of the invention in controversy, and is adapted to perform the work for which it was intended and actually did such work, such a device is a reduction to practice.

Where, after the issue of an original patent and before an application for there issue of the same, it is shown that other parties were using the subject matter not claimed, then the patentee has abandoned his right to a reissue to claim such matter, by his delay in not applying for the reissue before the rights of other parties accrued.

In determining the question of rights intervening after the grant of a patent and before an application for a reissue, the Patent Office does not decide whether any of the claims of the original patent are infringed. The question of an infringement is not involved.

An exclusive license for a consideration by a corporation, to a person assigning to it his patent to manufacture and sell, as agent upon his own account, subject to uniform terms and conditions, the corporation itself agreeing not to manufacture, is part of an illegal combination and in unwarrantable restraint of trade. Combinations between a number of persons engaged in the same general business to prevent competition and maintain prices, being against public policy and illegal, the same principle, notwithstanding the patentee's exclusive control of his invention, is applicable in questions concerning patents.

A BIOGRAPHICAL HISTORY OF ELECTRICITY.

With the name of Coulomb comes up the vexed question as to the relative proportion of credit due to the original discoverer of a law, principle or invention, and to one who, though coming later, yet independently makes the same discovery, and is the first to communicate it to the world, thereby, through the results which directly follow, conferring a benefit upon mankind, or opening up a new era in thought or science.

The comparatively recent publication of the electrical researches of Cavendish has shown that as early as 1772, the eccentric Englishman had demonstrated, by methods even more rigorous than those of Coulomb, the law of inverse squares with respect to electrical attraction and repulsion. Nevertheless, the demonstration by Coulomb, thirteen or fourteen years later, of the same law is what laid the foundation of exact electrical science, and the prior work of Cavendish—only revealed to the world when it had become an antiquity in scientific knowledge —should not detract one iota from the fame of the French scientist.

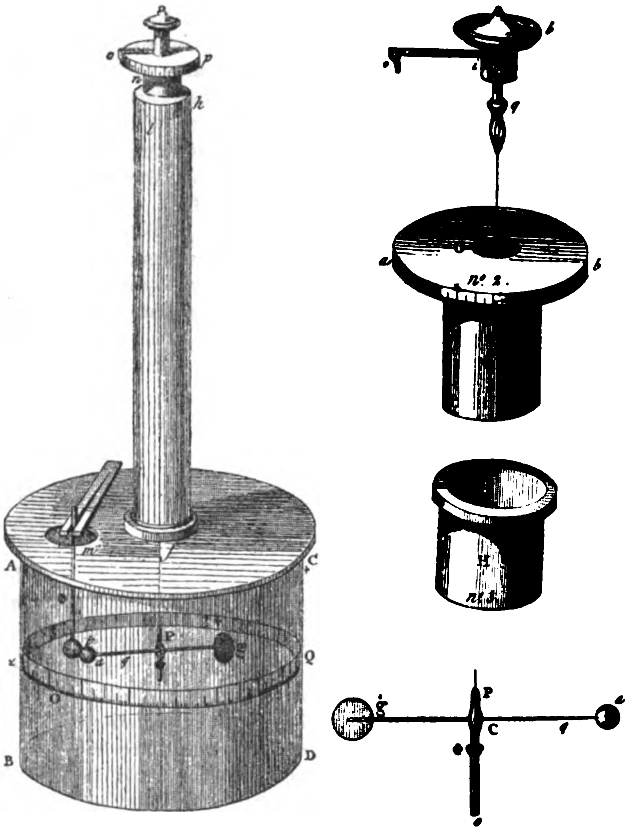
Charles Augustin de Coulomb (1736-1806) came of a family of magistrates, and in early years showed a decided aptitude for science and mathematics. Entering, at an early age, the corps of military engineers, he spent nine years in Martinique, West Indies, where he built Fort Bourbon. In 1776 he published a memoir on elasticity and torsion, which first established some of the laws relating to these branches. In 1779 he divided with another a prize offered by the Académie (afterwards the Institut) for a paper on the best construction of ships' compasses, and two years later obtained a prize from the same source on the theory of simple machines.

From 1785 to 1789 Coulomb published his fundamental memoirs on the laws of electricity and magnetism, in which he applied to the measurement of electrical and magnetic attraction and repulsion, and to the study of distribution of static electricity, the principles of torsion as established in his paper of 1776. At the beginning of the French revolution he occupied a number of positions of honor and profit, of which he was deprived on account of the law expelling nobles. Later, when the Académie was revived in the Institut, he returned to Paris, but thenceforth made no notable contributions to science.

When Guericke or Gilbert, brought up in the speculative school of thought which so long ruled the world, made a discovery, he never thought of submitting the phenomenon to measurement, but at once proceeded to build up grandiloquent hypotheses resting on no quantitative basis, his aspirations apparently being impatient of the trammels of numbers. Even one so practical as Franklin did not think of making quantitative measurements. Coulomb, on the contrary, was always occupied with the absolute value of the forces with which he dealt, and, therefore, instead of merely originating hypotheses, established laws.

The work of Coulomb consisted in establishing the electrical and magnetic laws of attraction and repulsion. He demonstrated that the internal surface of a conducting body cannot be charged with static electricity; proving that electricity only distributes itself by virtue of its own repulsion, he showed that, therefore, it can only be found in a state of equilibrium on the surface. He originated the torsion balance method of measurement and the proof plane, by means of the latter studying the distribution of electricity and showing that the density at any point is proportional to the force there existing.

A German writer has said that the entire mathematical treatment of magnetic and electrostatic phenomena, as it exists to-day in the potential theory and its applications, has been built upon the work of Coulomb, and that his labors for a long time were the exclusive basis of physics. The same writer remarks that, unlike Faraday, Coulomb regarded the forces he measured as proceeding from phenomena whose causes he felt no more under the necessity of seeking than for those of the force of gravity. His work was free of all speculation and directed exclusively toward determining a knowledge of the laws of phenomena, and the formulating of this knowledge with respect to customary ideas independent of hypothesis, such an expression of facts being at once the simplest and the only one adapted to all times. In this respect, he adds, the labors of Coulomb are for all time models of experimental investigation, and their appreciation increases when it is realized that they were the first measurements in the domain of electricity, while the methods of measurements thus introduced into science by him are to this day the most indispensable means of the physicist.



COULOMB'S ORIGINAL APPARATUS.

The accompanying engraving is a reproduction of the original illustration of the apparatus used by Coulomb in his experiments to establish the laws of electrical attraction and repulsion. It consisted of a glass cylinder, *A B C D*, about 12 ins. in diameter and 12 ins. high, covered by a glass plate. In this plate were two circular holes, over one of which was secured a glass tube, 1¾ ins. in diameter and 2 ft. high.

In the upper end of the tube was fitted a hollow plug having its rim calibrated in degrees, and in the plug a torsion head having a pointer that played over the calibrated rim, the fit in each case being snug. To the torsion head, by means of a device like a crayon holder, was secured a steel torsion wire, to whose lower extremity was made fast in like manner a holder similar to that at the upper extremity. Through a hole in this latter was passed a rod made of shellaced silken threads, on one end of which was secured a gilded pith ball, *a*, and on the other a paper disk, *g*. Through the other opening in the glass cover was passed a similar pith ball, its shellaced thread support being held by a split piece of wood resting on the cover.

The manner in which the experiment may be repeated is as follows:

The fixed pith ball having been introduced, without charge, into the cylinder, the torsion head is so moved that the suspended ball just touches it, and at the same time is radially opposite the zero mark on the scale about the middle of the cylinder; the tube plug is then moved until the torsion head pointer is over the zero of the scale on the plug rim. Both balls being now electrified in the same sense from an exterior source, the suspended ball is repelled, thereby twisting the wire. By turning the torsion head in the opposite direction to the twist, the suspended ball, of course, is approached to the fixed one, and an increased number of turns is found necessary to move the ball for each division of the cylinder scale that it is approached to the fixed ball.

Coulomb had in his early scientific work determined the laws of torsion, and, therefore, by observing the rate at which the increase of turns of the torsion head grew as the distance between the pith balls was uniformly and successively decreased, he was enabled by a simple calculation to find that the force of repulsion between the balls varied inversely as their distance apart.

As stated before, Coulomb made no attempt to explain the mechanism of repulsion or attraction, being content to measure the effect. It was not until Faraday, whose deep-seeking mind found "action-at-a-distance" nothing but a formula hiding the absence of even a hypothesis—that the dielectric or medium was looked upon as the agency through which a force produces an effect.

An extended search in libraries and numerous inquiries have brought to light no source from which a portrait of Coulomb could be obtained. Steps have been taken, however, to obtain a photograph of a bust in Paris, from which an engraving will be made and printed in a future issue.

LESSONS IN PRACTICAL ELECTRICITY

GENERATORS OF CONTINUOUS CURRENTS.

In order to make this article as far as possible complete in itself, the fundamental principles relating to the generation of E. M. F. will be reviewed.

When a conductor cuts lines of force, there is generated in it an E. M. F. In absolute units the value of this E. M. F. is expressed by the number of lines cut per second; in practical units or volts, it is the number of the lines cut divided by 100,000,000 (10^8). Referring to Fig. 1, which represents an armature in a bi-polar field, it will be seen that while a wire on the armature moves from *A* to *B*, but few lines will be cut, while when moving from *I* to *J*, the rate of cutting is a maximum; in the above case the ratio of the E. M. Fs. generated in cutting through *A B* and in cutting through *I J* are as 12 to 156.

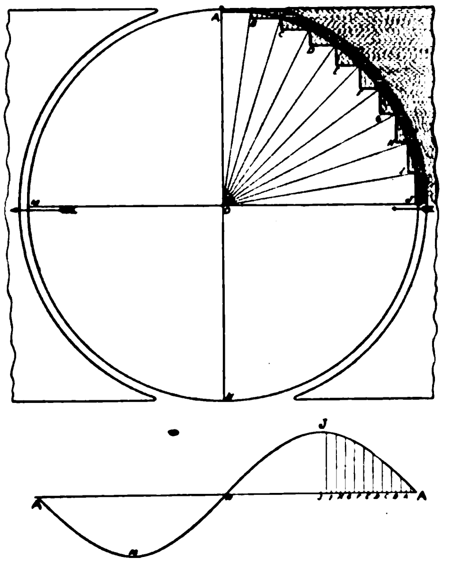
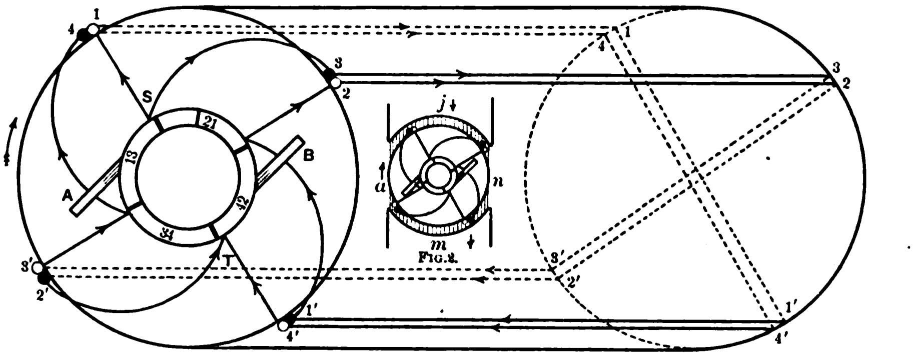


FIG. 1.—ARMATURE CONDUCTOR IN BI-POLAR FIELD.

If a bi-polar field is laid down to scale as in Fig. 1, and the number of lines counted in each of the equal divisions into which the circumference of the armature may be divided, a curve can be constructed from these numbers which will show how the E. M. F. in an armature conductor in a bi-polar field varies in a revolution, armature reaction and distortion of field being neglected. In Fig. 1 such a curve is shown. It will be seen that when a wire is at *A*, there is no E. M. F. since it is cutting no lines; while at *J* the rate of cutting is a maximum, and the curve reaches its highest point. Supposing that it takes one second for a wire to pass over each of the divisions of a revolution, then the E. M. F. in the division, *A B*, will be 1.2 absolute units, and 15.6 in the division, *I J*. From *J* to *N* the reverse operation occurs, since the wire in each succeeding division cuts less lines. From *N* to *M* to *A* the cutting is the same as in the right half, but since the lines are cut in an opposite direction, the E. M. F. is opposite in direction and, therefore, negative. The curve thus obtained is known as a sine curve, which name is derived from the equation expressing the curve.

In the armature wires of all commercial forms of dynamos, an alternating or sinusoidal E. M. F. such as just described is generated, but by the employment of a commutator, the E. M. Fs. of the several armature wires are added together in such a manner that the E. M. F. at the brushes is practically constant. The object of this article is to explain how this is done.

Figs. 2 and 3 represent a Siemens drum armature with a four-part commutator. As just stated, as the armature revolves an alternating E. M. F. is generated in each of the wires shown, and by following up the windings, the manner in which these separate E. M. Fs. are added will be made clear. We will commence at the brush, *A*, and commutator segment, 13, and follow from *S* the wire 1. The arrow shows the direction of the E. M. F. generated in 1-1; as the wire, 1'-1', with which it connects is cutting lines of force in an opposite direction, its E. M. F. will be opposite to that of 1-1, but as the direction with respect to the commutator is also opposite, its E. M. F. will consequently be added to that generated in 1-1. The end of the 1'-1' connects to the commutator segment, 21, and by tracing the winding it will be seen that the E. M. Fs. generated in the wires 2-2 and 2'-2' will also be added in the same manner as was that generated in 1'-1'. Finally, the end of 2' comes to the brush commutator segment, 42, opposite to the one from which 1 started. If, now, the other circuit (numbered 3 and 4), starting from *S*, is followed, it will be found that exactly the same actions occur as in the circuit just considered.



FIGS. 2 AND 3.—SIEMENS DRUM WITH FOUR-PART COMMUTATOR.

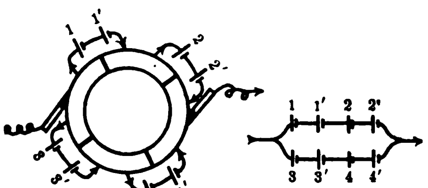
The actions described are further represented in Figs. 4 and 5, from which it will be seen (Fig. 4) that the case is similar to that of connecting up voltaic cells, the E. M. Fs. of the latter corresponding to the E. M. Fs. generated in the several armature wires. Fig. 5 represents the same thing diagrammatically, and shows that in a bi-polar dynamo the E. M. Fs. are joined up by the commutator into two series in multiple, in precisely the same manner that batteries are joined in series-multiple; each wire on the cylindrical surface of the armature corresponds to a voltaic cell, with, however, the difference that the E. M. F. of a cell is constant, while that of a wire changes with every change of position due to the revolution of the armature.

Thus far we have only considered the case of the E. M. F. at a single instant of time, and have explained only one of the two functions of the commutator—that of adding together E. M. Fs. and forming them into two series in parallel. We will next take up the commutator in motion and show how it delivers, with a sufficient number of segments, a practically continuous current.

Referring to Figs. 2 and 3, it will be seen that when the armature wires 1 and 4 are at *a*, the brush, *A*, will be just passing to the segment 13 to which 1 connects; also, since a four-part commutator it used, when 1 and 4 are at *a* where the field has no strength, 3 and 2 will be at *j* where the field strength is a maximum. Similarly, 1' and 4' will be at *n* and 3' and 2' at *m*, and the brush, *B*, will be just passing from segment 34 to 42.

Now, since the brushes, *A* and *B*, will remain on the segment while the armature is passing through a quarter revolution, the wires 1 and 4 will pass from *a* to *j* in that time; the wires 2 and 3 from *j* to *n*; the wires 1' and 4' from *n* to *m*, and the wires 2' and 3' from *m* to *a*. Taking up only one of the two parallel armature circuits or 1-1'-2-2', and referring to Fig. 1, it will be seen that during such quarter revolution, the E. M. F. of 1 will have increased from *A* or zero to *J* or a maximum; the E. M. F. of 1' will have decreased from *N* or zero to *M* or a negative maximum; the E. M. F. of 2 will have decreased from *J* to *N*, and that of 2' increased from *M* to *A*.

While half of the separate E. M. Fs. generated during this quarter revolution are positive and half negative, it has been shown that, owing to the manner in which the windings connect to the commutator, the several E. M. Fs. add as if all were positive. This addition is made in Fig. 6 for a quarter revolution; the fractional parts (one-fourth in this instance) of the curves mentioned in the preceding paragraph are laid down in full lines, and the sum of the several E. M. Fs. which they represent is indicated by the upper figure, this resultant E. M. F. being measured from the base line to the boundary curve.



FIGS. 4 AND 5.—ARMATURE E. M. FS.

At the position in which the armature is shown in Fig. 3, the values of the E. M. Fs.

at that instant in the wires 1, 1′, 2 and 2′ are represented by the length of the lines, *LK*, *KT*, *SP* and *PR*, respectively, and the sum of these lines is represented by *FG* in the figure of resultant E. M. F., or the E. M. F. which appears at the brushes. When the wire 1 is at *a* (Fig. 2) the brush E. M. F. is that due to the wires 2 and 2′ alone, while when 1 is at *b* the brush E. M. F. is due to 1 and 1′ alone, 2 and 2′ being now at *n* and *a* where there it no field. It will thus be seen that while the E. M. F. in each of the four wires is varying between zero and a positive or negative maximum, the E. M. F. at the brushes only varies between limits represented by *j m* and *FG*.

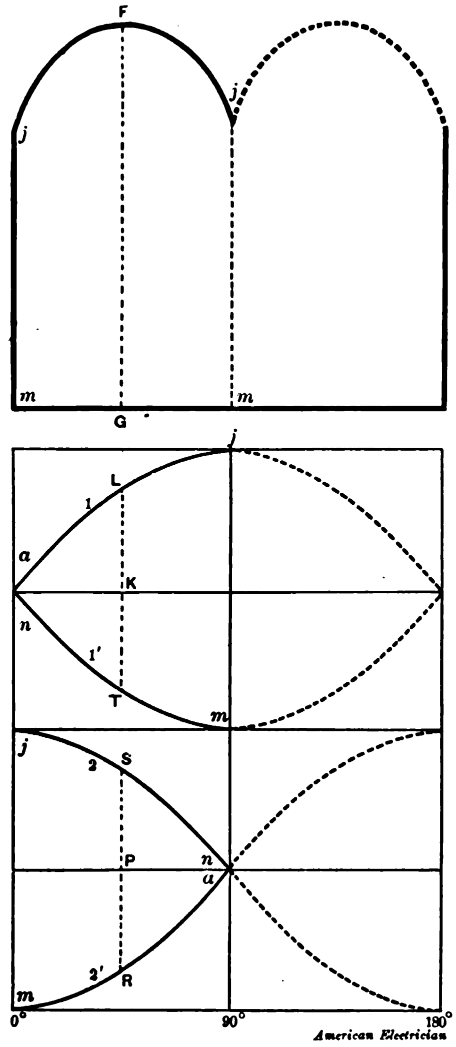


FIG. 6.—CURVE OF E. M. F. WITH FOUR-PART COMMUTATOR.

We have thus far only considered a quarter revolution. Referring again to Figs. 2 and 3, it is evident that when the brushes, *A* and *B*, pass from 13 and 42 to 24 and 21 respectively, the two new circuits have precisely the same relation with respect to the brushes as had the two former ones, and therefore the events of the preceding quarter revolution will be exactly duplicated, and so on for each succeeding quarter revolution. In Fig. 6 the dotted half of the curves shows the new condition. The brushes passing to other segments have merely changed the respective relations to each other of the separate armature wires, which continue to add their E. M. Fs. together as before, though in another order; neither has the change affected in any manner the individual armature wires, which always continue to generate an alternating or sine E. M. F. as in Fig. 1. In Fig. 6 the E. M. F. curve is shown only for a half revolution; if for a full revolution or more the parts of the curves of 1, 1′, 2 and 2′ would be merely duplicated.

The upper or brush curve of E. M. F. has, it will be seen, four variations corresponding to *j*, *F*, *j* for each revolution. With an eight-part commutator, these variations would be reduced as shown in Fig. 7. With a twenty-part commutator the fluctuations are less than one per cent. and therefore ordinarily negligible, while the fluctuations with the number of segments used in practice are so small that they can only be detected by means of the telephone.

From what precedes it will be seen that a commutator has two functions: First, to add to the E. M. Fs. generated in the individual armature wires; second, to divide into small sections the sine variation of E. M. F. in the individual wires, such that when the E. M. Fs. of the various wires are added, a decreasing E. M. F. in one will be offset by an increasing E. M. F. in another, thereby, with a sufficient number of segments, approximating to a constant brush E. M. F.

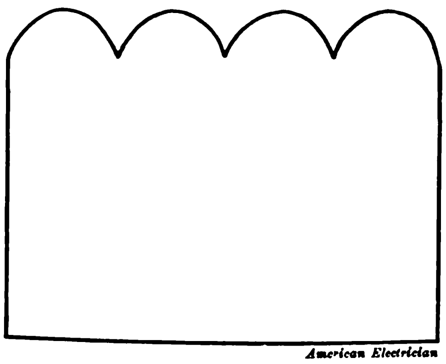


FIG. 7.—CURVE OF E. M. F. WITH EIGHT-PART COMMUTATOR.

◆

The English Municipal Electrical Engineer.

The editor of the London *Electrician* recently inquired of a municipal electrical engineer why the station over which he presides had been so long a building. His reply was somewhat as follows: "The prevailing feature in my Electricity Committee is that it will rarely decide anything that can be deferred until the following week. On my appointment I found that an idea possessed the members of committee that they could erect the proposed electricity works on a hopelessly small site, and it took me some time to rid them of this notion. Thereupon a member of the committee took upon himself to find a suitable site; but being a busy man he was unable to devote much time to the job, and thus several months were lost. A sub-committee was then formed to make the usual grand tour; but as it was composed of extremely busy gentlemen, it was not until some nine months that the tour commenced. Specifications were then drawn up, and a large number of tenders were received, and considerable time was occupied in examining them and preparing the necessary report. The report was referred to the sub-committee, which devoted considerable time to its consideration, though the difficulty was to induce the sub-committee to meet. The main cause of delay was, therefore, the anxiety of officials to see to everything themselves.

Letters from Practical Men

Transformer Primary Turns and Secondary Voltage.

Observing the query of O. F. L. as to the effect of increasing the primary turns of a transformer, on page 177 of your September issue, and your answer to the same, we thought it might be of interest to some of your readers to mention a practical case confirming the information there given. In the case referred to, part of the winding had been removed from the primary of a transformer, with the result of *increasing* the secondary E. M. F. considerably. The reason for this increase is obvious from your answer to O. F. L., but the subject is one not generally understood.

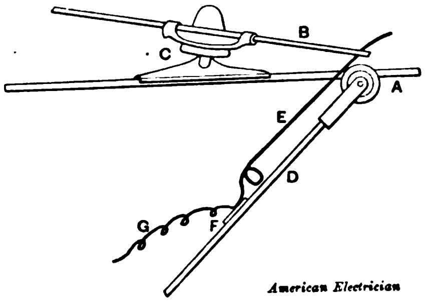
BAECHTOLD & PARKER.

◆

Test of Span Wire Insulation.

A large majority of the trolley roads in operation at the present day use what is known as the "West End" type of trolley wire hangers. Probably a large proportion of these roads have more or less trouble due to defective insulation at the bolts connecting the ear to the body. Owing to the fact that the span wire is insulated at the point where fastened to the pole, thereby constituting a double insulation between the trolley wire and the ground, it oftentimes requires considerable time and bother to locate the particular bolt or bolts which are defective; either the insulation at the bolt or at the pole may be defective, and the other one being perfect, an ordinary insulation test may fail to disclose any leak.

In order to avoid the tiresome method usually employed to locate faulty insulation on span wires, the writer has devised certain attachments which may be placed upon any car, and which will indicate by simply running the car over the road, any defect in the insulation, either at the pole or at the hanger. It can be easily explained by reference to the accompanying diagram, in which *A* is the trolley wire, *B* the span wire, *C* the hanger, *D* the trolley pole, *E* a spring attached to the trolley pole, but insulated from the pole by the block of wood at *F*; *G* is a flexible cable leading down into the car, where it is attached to one side of a voltmeter.



As the car passes over the road, the spring, *E*, comes in contact with the span wire, *B*. If the insulation in the hanger is defective thereby making the span wire alive, the current will flow down the cable, *G*, to the voltmeter; the other side of the voltmeter being grounded, the needle will indicate the potential of the span wire. On account of the short time of contact owing to the speed at which the car is traveling, the voltage reading will not rise to the full voltage of the line, but will probably indicate from 40 to 50 volts, although the actual voltage of the span may be 500.

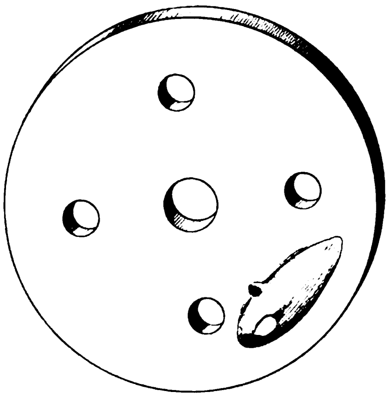
In case the insulations at the poles are defective, it will be necessary to reverse the connections at the voltmeter, connecting one side to the trolley and the other side to the cable, *G*; in this case, where the span is grounded the current will flow through *E* to the span and ground, causing the needle to indicate as before.

Francis G. Daniell.

◆

A Singular Accident.

The accompanying sketch illustrates what a catalogue of evils may result from a small cause. The sketch represents the follower plate of an 8½ × 10 engine, making 320 r. p. m., located at 35 Bridge Street, New York, and was furnished by the courtesy of Mr. Mayglothling, the chief engineer. Upon his return from a temporary absence of about three months, he noted an increase in the coal consumption from 1500 to 3000 lbs. An application of the indicator showed an increase in back pressure of about 11 lbs. The cylinder head was removed and an opening about ½ in. in area was found through the piston, that in the piston head corresponding almost exactly in shape and size with the hole in the follower.



This opening had been gradually worn through both the piston head and follower plate by one of the bolts used to set out the packing springs, which had become loose and struck the piston head or follower at each change of stroke; its travel was about 1 in. to start with, and about 2½ ins. finally. It also developed that before Mr. Mayglothling's return this hole had become large enough to allow the bolt to pass out and enter the valve chest, which resulted in the breaking of the rocker arm. This was repaired and no examination made, as the man then in charge of the engine assumed that the bolt came from the feed-water heater!

When the real cause of the leakage was discovered a new piston was provided, and the coal consumption was reduced to the normal amount.

In order to maintain the speed before the leak was discovered, the governor springs had been tightened to the fullest extent, and under the maximum load the speed would fall about fifty revolutions; the consequence of this was that, the lights run from the dynamo operated by the engine were unsatisfactory. Still another consequence was, that owing to the largely increased demand for steam, the boiler was fired so strongly that the damper was burnt out.

A. C. Lippencott.

◆

A Suggestion For An Instructive Experiment.

The experiment suggested by your correspondent—"A Suggestion for an Instructive Experiment"—would certainly succeed. He will find practically the same experiment described in many text books, and apparatus for performing it will be found figured and described in the catalogues of physical instrument makers.

Lines making "a complete circuit in the air without any mechanical obstruction" do not exist in the space enclosed by an iron ring wound with a coil of wire. It must be remembered that the lines of force produced by a coil of wire are the resultants of the elementary lines surrounding each individual wire of the coil. Every such line must, therefore, for a part of its length, pass inside the coil. As a matter of fact, the lines of force produced by a coil wound on an iron ring are almost entirely confined to the ring itself, for the reason that the ring offers the path of least resistance.

So with the permanent magnets referred to by your correspondent. The lines of force when the four magnets are joined to form a square, are withdrawn from the air space and pass through the bars.

A single bar magnet gives rise to lines of force extending through the air from *N* to *S* and through the magnet from *S* to *N*. If four such magnets are joined as your correspondent suggests, the lines of force of any magnet instead of being completed through the air, will be completed through the other magnets—that is, will join on to and become a part of the lines already existing in the other magnets. If perfect contact could be secured between the poles of four equal magnets, no magnetic force whatever would be found in the air space.

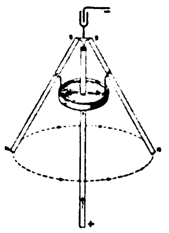
Wm. A. Anthony.

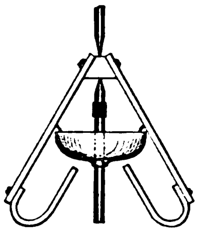
The communication of "Electrician" on page 175 of your September issue, raises some interesting theoretical points. In the first place, the apparatus illustrated ought to revolve according to theory, and in the second place it does revolve if the experiment be properly tried.

The criterion of continuous rotation in an apparatus of this sort is this: If it revolves it must obtain its supply of energy from the electric current, and it is therefore only a particular form of electric motor, and like other electric motors, it must somewhere generate a counter E. M. F. In other words, if revolved mechanically, it must be a dynamo and generate a current.

In the apparatus herewith described, the lines of force from *N* to *S* pass through the mercury trough, so that the rotation of the movable member causes the lines of force to cut the mercury. There should therefore be a torque, and if the apparatus moves easily enough, a rotation.

If anyone wishes to repeat the experiment, he should observe the following precautions: The magnets should be as strong as possible for their weight, there should be a considerable length of vertical conductor both above and below the revolving parts so as to keep the horizontal leads well away from the magnets, the first should be well made to reduce the friction, the lower mercury trough should be as large in diameter as the magnets will allow, the mercury should be clean, and the contacts so arranged that on the one hand they are large enough to allow the passage of a heavy current, yet on the other hand they do not offer too much resistance to motion.





In an experiment tried by the writer with the assistance of Mr. E. V. Baillard, two sections of a compound magnet from a telephone receiver were used, and the pivot was moderately well made, but was not a jewel center. Forty amperes were required to start a rotation of any certainty. Pole shoes of iron were then attached as shown in Fig. 2, with the result of improving the rotation.

This is conclusive proof that the origin of the torque is in the cutting of the magnet field by the mercury, for the pole shoes do not increase the strength of the poles, but only the number of lines of force through the mercury. If the rotation attains any considerable value, the mercury is liable to begin to move itself by reason of the mechanical action of the contacts, which reduces the tendency to rotation of the magnets.

This is not a perpetual motion apparatus, as the energy evidently comes from the electric current. The iron ring wound with wire and the bar magnets arranged in closed magnetic circuit, do not produce lines of force entirely in the air space. The lines of force from a permanent magnet, or from the core of an electromagnet, always pass through the iron (or steel), and the effect of forming a complete magnetic circuit is to remove the lines from the air. In the case of a perfectly uniform ring, there are absolutely no lines in the arc at all. In the foregoing experiment there is no part of the torque due to the current in the vertical part of the conductor. This would seem to contradict the usual statement of the text books quoted by "Electrician," but whether it does or not depends upon the exact form in which the statement is made, and the discussion of this point would occupy too much space for this letter.

Townsend Wolcott.

ELECTRICAL CATECHISM

52. Can two arc dynamos be coupled together so as to work on the same circuit?

This is frequently done. The two machines are connected in series so that the same current passes through each and the voltage of one is added to that of the other. Connect the positive terminal of No. 1 to negative terminal of No. 2; connect the positive line terminal to positive terminal of No. 2; connect the negative line terminal to negative terminal of No. 1 as indicated in Fig. 1.

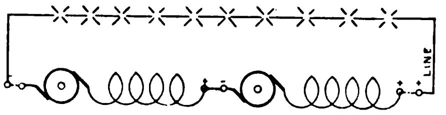


FIG. 1.

53. What advantages are there in coupling two arc dynamos in series?

Coupling two machines in series gives a higher voltage and so allows more arc lamps to be connected on one circuit. By thus using one long circuit instead of two or more shorter ones, considerable wire is saved in returning to the station and so less electrical energy is lost on the line. Again, the circuits may become so loaded that they are not even loads for the dynamos and some machines would carry less than full load while others would have an overload. By connecting several circuits and several dynamos in one circuit, it is often possible to arrange that each dynamo works at full load.

54. Is it true that two arc dynamos of equal size connected in series can operate more than twice as many lamps than one alone?

This is sometimes found to be true. It is probably due to the fact that in a long circuit with many lamps, the fluctuations due to the feeding of the lamps become more uniform as a smaller proportion are feeding at the same time. This allows the dynamos to work with less margin for fluctuation.

55. Is it not dangerous to connect several arc machines in series?

It is to some extent. Of course, the voltage is higher and it is necessary to have the lines, lamps and machines well insulated. The liability to getting a serious or fatal shock is increased, but no one has any business handling an arc circuit, unless he uses proper precautions, and to most people it would make little difference whether the shock was from 2000 or 10,000 volts.

56. How are the machines started when two are coupled in series?

Make all the connections and then bring both machines up to speed gradually and together. Or, if this is not convenient or desirable, move the brushes or regulator of each machine to the position of no load and then throw in both machines at once.

57. How are two or more incandescent dynamos coupled for combined output?

The two machines are generally connected in parallel or in multiple on the same mains, as indicated in Fig. 2. Both machines are regulated to give practically the same voltage and current.

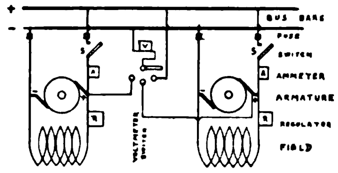


FIG. 2.

58. When two incandescent dynamos are to supply the same mains, how may the two be started safely?

This depends upon the load. If it comes on all at once, both machines should be started at the same time. Connect both machines to the circuit and bring both up to speed gradually. Watch the ammeters and adjust the regulators so that both machines may pick up at the same rate and each take its proper share of the load. If the load comes on gradually so that one machine can carry it all for some time another method is used.

59. How can an incandescent dynamo be safely coupled in parallel with another one already working?

Bring the second machine up to speed and adjust it until it gives the same voltage as the one already working and then close the switch so as to connect the two machines in parallel. A convenient way to do this is to have a voltmeter with a switch having three or more points as shown in Fig. 2. One side of the voltmeter is connected permanently to one of the mains, to which also one side of each dynamo is connected. Suppose the machine at the left is already connected to the mains and is at work, its main switch, *S*, being, of course, closed. Move the voltmeter switch so as to measure the voltage of the line or, what is the same thing, the voltage of the machine at work. Then throw the switch over to measure the voltage on the fresh machine. Adjust the rheostat or regulator of the fresh machine until its voltage is just the same or a trifle higher than than that on the other machine. When the voltage of the fresh machine is just right, close its switch, *S*. This should cause no disturbance whatever, and the switch may be opened or closed without any flash or fluctuation of voltage. After the switch is closed, the regulator of the fresh machine should be moved so as to make it pick up its share of the load, while at the same time the regulator of the warm machine should be moved in the opposite direction so as to throw off some of the load to the fresh machine.

60. How can one tell whether each machine is taking its proper share of the load?

Each machine should have its own ammeter (sometimes called ampere-meter or current indicator) which will show at all times the current being supplied. If the machines are all of the same size, the attendant should so adjust the rheostats and brushes that each machine may give the same current.

61. Is it practicable or desirable to couple a small dynamo in parallel with a large one?

There is no difficulty at all in doing this except to see that the smaller machine does not get more than its full share of the load.

62. Are not incandescent dynamos sometimes coupled by means of double-pole switches instead of single-pole switches, as indicated in Fig. 2?

Yes. Double pole switches are often used. They give the advantage that each dynamo is entirely isolated from the circuit when not working.

63. Are not galvanometers sometimes used instead of voltmeters for indicating when a dynamo is ready to be thrown into circuit?

Yes. A small switch is arranged so that the galvanometer may be connected between the two sides of the single-pole switch between the dynamo and the main. The galvanometer needle will then be thrown to one side if the voltage of the fresh dynamo is too low and to the other side if it is too high. When the voltage is just right, the galvanometer needle will not be deflected at all.

64. What will happen if the switch is closed before the fresh machine is quite up to the voltage on the line?

The fresh machine will take current from the line, running as a motor and increasing the load on the other dynamo. This may not do anything worse than cause the voltage on the line to drop to some extent, but it is not a good thing to do.

65. When a dynamo runs as a motor does it not run backwards, revolving in the opposite direction?

Not if it is an incandescent dynamo. Arc dynamos are usually series wound, that is, with the field coil in series with the line, and a series motor runs in the opposite direction from a series dynamo. But incandescent machines are usually shunt machines or sometimes compound wound. A shunt machine runs in the same direction whether as a dynamo or as a motor. A compound machine would run in the same direction as a motor unless the current were very heavy, when it might stop and then start in the opposite direction.

66. If two machines are working in parallel on the same circuit so that both give the same voltage, how is it possible to regulate the division of load between them?

This results from the fact that the voltage at the terminals of the dynamo is somewhat smaller than the total voltage induced in the armature wires. There is unavoidably more or less resistance in the armature wires, commutator, brushes and connections, so that the current suffers some loss of voltage before reaching the external circuit, the loss of voltage being equal to the product of the current by the resistance. When two machines are coupled in parallel, the voltage at the terminals must be the same for both. If the total voltage of either machine is increased, the current delivered by it increases until the lost voltage again equals the difference between the total and that on the line. When two machines are working together in parallel, if the total voltage of one is increased while the other is not changed, the voltage on the external circuit is raised slightly so that difference between the total and external voltage of the other machine becomes less. The result is that the first machine takes more of the load and the other less.

QUERIES AND ANSWERS

Is it feasible to run an induction coil from an alternating circuit? J. J.

Yes, by putting one or more incandescent lamps in series and throwing out the vibrator. See the article by Houston and Kennelly, page 117, August issue.

Do the fields of an alternating current fan motor act as a choking coil? J. O. H.

Any coil carrying an alternating current is a choking coil, whether without iron or when surrounding a field core. A motor, of course, is so designed that its proper working is not thereby affected.

How much would a storage battery cost to run 8 small incandescent lamps? W. M. T.

If the lamps are 8-CP, 3.1 watt, 12-volt battery lamps, the storage battery would cost about $60; one charging of the battery would run the lamps about 10 hours, when it would be necessary to connect it to a dynamo circuit for recharging. If the shop has an engine it would, of course, be much better to install a small incandescent lighting dynamo.

Why does a compound dynamo stop generating when the shunt wire is broken? F. G. H.

We doubt if a compound dynamo will stop generating if the shunt is broken, unless the load is small or the external circuit is open, though the voltage may drop so that the filaments of incandescent lamps in circuits will lose their incandescence. With the circuit closed, the series coil will give some voltage, though it may be small. In one experiment quoted by Esson, the voltage with the shunt coil alone was 100 and with the series coil alone 60.

What would be a suitable battery for a 6-CP incandescent lamp taking about 2 amperes at 10 volts? Are there any other battery lamps than the above, and how much current will they take? H. N. L.

Gordon-Burnham or Edison-Lalande cells would be suitable; about 11 cells of the former and 13 of the latter would be required. Battery lamps are usually of small candle-power on account of the great expense of running them from primary batteries. The current may be found by multiplying the candle-power by the watts per candle-power, and dividing by the volts. Taking the above instance and assuming 3.1 watts per candle-power, we have 6 × 3.1 divided by 10 = 1.86 amperes—nearly two amperes. Some battery lamps are made with an efficiency of 2.5 watts per candle-power, which, of course, reduces the current.

1°. Can gravity batteries connected in parallel run an Edison phonograph? 2°. What injury would result if a wire were connected across the terminals of a storage battery? 3°. What material should be used to stop a leak in a rubber storage battery case? 4°. What are the proportions of water and sulphuric acid for the electrolyte of a storage cell? C. H. P.

1°. No, on account of their large internal resistance. 2°. If the wire were small, it would be melted and no injury result; if large and kept in circuit, the plates would be apt to buckle and then scale on recharging. 3°. Melt together 100 parts of sulphur, 2 parts of tallow and two parts of resin, until they assume a brownish red color; add enough powdered glass to make a paste, heat the edges of the crack and apply hot. 4°. One part of acid to three parts of water.

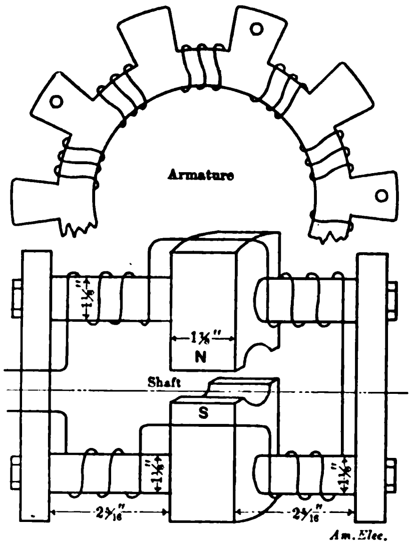
How can one tell, without running a generator, which direction the fields are wound, or is it customary to wind them right-handedly? F. G. F.

There is no convenient method of ascertaining which way the field is wound when the machine is not running, unless you know which is the positive brush. In that case, find the north pole-piece of the machine with a compass and trace the circuit from the positive brush to the coil on the limb of the north pole-piece; beginning where the wire enters that coil the winding goes around the core clock-wise, viewed from the back end of the core. It makes no difference electrically whether a coil is wound right or left handed; the magnetizing effect is reversed by exchanging the connections at the terminals of the coil.

What is the relation between volts, amperes, watts and horse-power? S.

Illustrating by the hydraulic analogy, the voltage corresponds to a head, and the current (amperage) to the flow per second, of water. The head of water in feet, multiplied by the flow in pounds per second, gives the foot-pound-seconds of energy or work in the water under the given head; similarly, the volts multiplied by the amperes gives the amount of energy per second of a current under a given voltage. There is no specific name for the mechanical foot-pound-second unit, but the volt-ampere unit is known as the watt. There are 550 foot-pound-seconds or mechanical units (33,000 foot-pound-minutes) in a horse-power, while there are 746 volt-amperes or watts to the horse-power. It has been proposed to increase the horse-power so to as contain 737 of the above mechanical units and 1000 watts, or a kilowatt.

Please inform me what size wire I should use on the machine shown in the accompanying sketch.

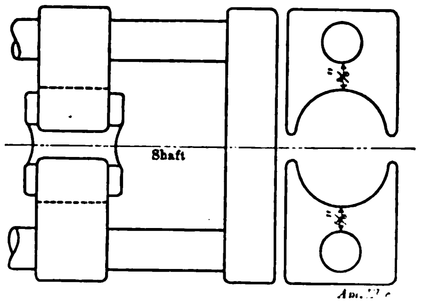


The bore of the field is 3 ins., and the other dimensions are given in the figure. H. L. H.

Wind the field coil with No. 25 double cotton-covered wire, 19 layers deep and each coil 75 turns long, making 5700 turns of wire in all four coils; take care to put the same number of turns in each coil (1425).

Wind the armature with No. 21 double cotton-covered wire, 92 turns (or as many more as you can safely put in) per slot; be careful to get the same number in every slot. Connect the field in shunt to the brushes and run the armature at about 2800 r. p. m.

The pole-pieces should be bored out 3 5/16 ins. in diameter, and there must be a clear space of ⅝ in. from the armature chamber to the nearest edge of the magnet limb, as indicated in the accompanying sketch.



Otherwise the armature wire will rub against the field coil. The data above given is based upon the use of wrought iron magnets; if your field frame is cast iron the machine will not operate with any degree of satisfaction. The corners of the pole-pieces and yokes should be rounded off as shown in the sketch, in order to reduce the magnetic leakage, which at the best is high in miniature machines.

The armature slots should be the same width top and bottom so as to make the ends of the teeth wider and reduce the reluctance. The machine would also be of better design if the field magnet cores or limbs were made 1½ ins. in diameter instead of 1⅛ ins.; as it is now the iron of the armature core is worked at low efficiency. Should you change the cores to 1½ ins. in diameter, you can wind the armature with No. 18 wire, 51 or 52 turns per slot, and the field with No. 24 wire, 16 layers deep, each coil 70 turns in length (making 1120 turns per coil. The machine wound either way will give about 50 volts, but with the large cores and winding last given, the sparking will be greatly reduced and the capacity of the machine nearly doubled.

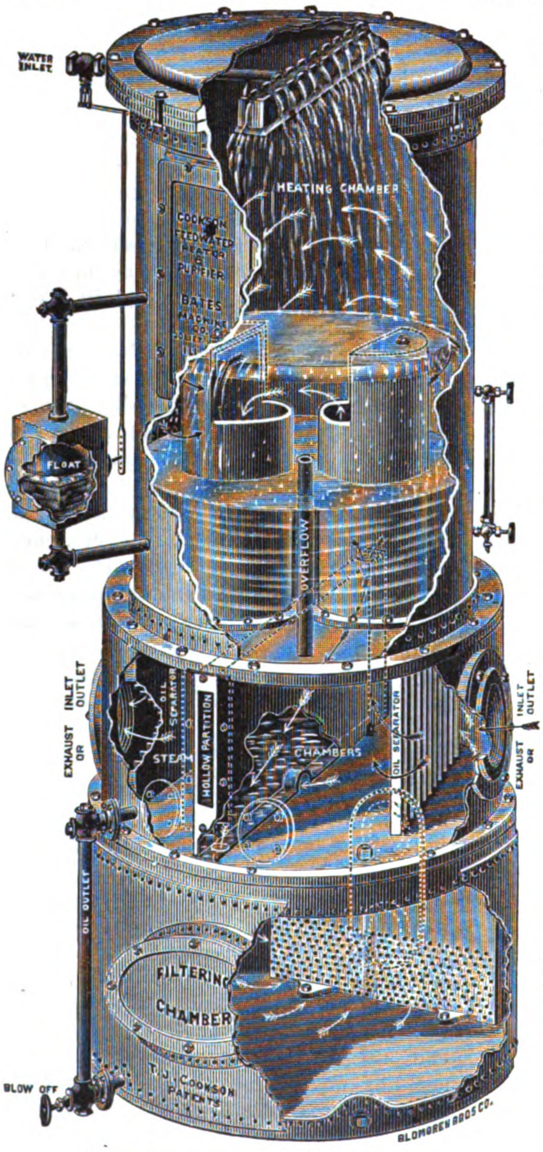
Of what use is the resistance in an arc lamp? W. H. W.

1°. In a series lamp, the resistance is used in connection with the cut-out, shunting, when the latter is closed, enough current into the series coil to strike the arc, and is then thrown out of circuit. Without such a resistance, when a series lamp is put in circuit, the current would pass out directly again by way of the cut-out contact, since the resistance of the latter is much less than the resistance of the other circuit open through the series coil, and the arc would not be struck. The resistance comes between the two ends of the series coil. 2°. The object of a resistance in a constant potential lamp is to steady the current, its presence keeping the increase at abnormal moments within a fixed limit. Without such a resistance, the current when the carbons were in contact would be excessive. The amount of this steadying resistance (which should not be confounded with that necessary to bring the voltage of a circuit down to that of the lamp) is that necessary to produce a drop of about ten volts.

NEW Apparatus AND Appliances.

COMBINATION FEED WATER HEATER, PURIFIER, FILTER AND OIL SEPARATOR.

As shown in the accompanying engraving, exhaust steam enters the heater casing at the right, where it strikes the oil separating plate, is relieved of its oil, and then passes through a large tube to the upper part of the case, where the steam meets a spray of cold feed-water. The uncondensed portion of steam is led off through the second vertical tube shown, from which it passes around either side of the left separating plate, where the moisture is separated on the same principle as the oil on the plate opposite the inlet. The steam then passes to the atmosphere.



COOKSON HEATER AND PURIFIER.

On the top of the two vertical tubes is placed a pan which prevents the spray of water from passing down their sides. The water is admitted at the top of the heater from the side and discharges into a receiver or spray box. The water overflowing this spray box falls through the steam and is thoroughly heated. It will be noticed that the current of exhaust steam is such with relation to the spray of water, that it is impossible to carry water out with it. The water spraying from the top of the heater condenses the steam and forms a vacuum, which draws the required amount to heat the water. The water, after having been thoroughly heated in direct contact with the steam, passes into the hollow partition dividing the two exhaust chambers, where it is further heated by having steam constantly on both sides of it, the steam entering at the back of the partition and discharging at the front end into the filter.

The filter is of large proportion and preferably filled with Excelsior shavings. The supply of water to the heater is regulated automatically by a float, which opens and closes the inlet valve to admit the required amount of water and thus at all times maintains a uniform water level. The float is in a case by itself and thus will not scale over. An overflow pipe is placed on the inside of the upper chamber, which discharges into the exhaust chamber and is drained through the oil outlet.

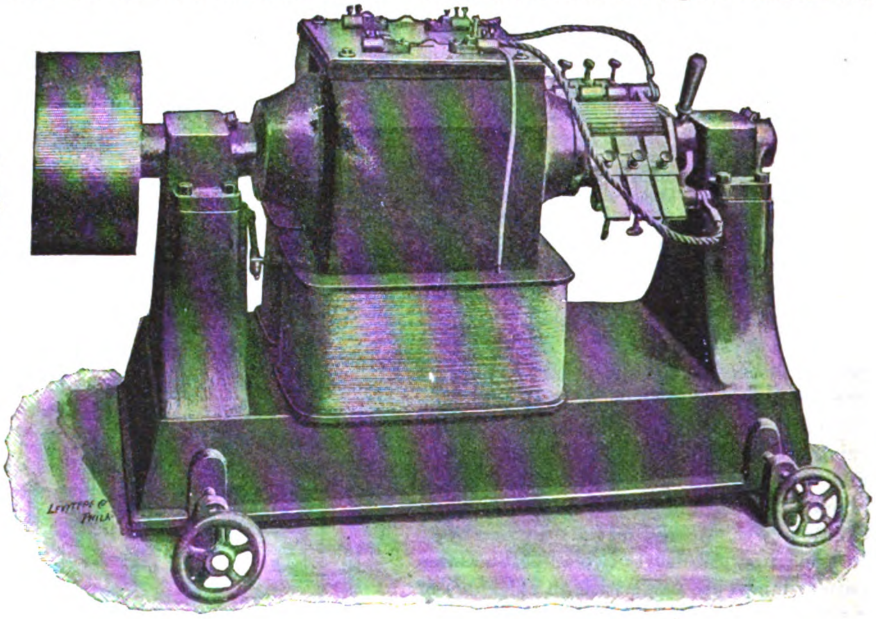
The Cookson feedwater heater, purifier, filter and oil separator is made by the Bates Machine Company, Joliet, Ill.

QUAKER CITY DYNAMO.

The type of dynamo illustrated in the accompanying engraving is built from designs embodying the very latest knowledge relating to the principles concerned in electrical generation, and in their manufacture the best materials and highest grade of workmanship are employed. They are of moderate speed, free of complication, and particularly quiet and smooth in running.

The frame, which comprises the bed-plate, bearing pedestals and field magnet cores, is one solid, soft steel casting, which, being entirely without joints, insures perfect alignment, absolute rigidity, and a perfectly centered armature at all times. The bearings are of an improved self-oiling type, lined with phosphor-bronze bushings of large bearing surface, thus insuring cool running. The shaft is of large diameter, and made of the best forged steel. The commutator is of pure hardened copper of large radial depth for wear, and insulated under pressure. The field magnets are wound on standard "forms" of insulating material, insuring interchangeability, should occasion require. The terminal blocks are of polished slate, mounted on the top of machines, into the binding posts of which all connections are made.

The above machine is made by the Quaker City Electric Company, of Philadelphia.


LEVYTYPE CO PHILA.

QUAKER CITY DYNAMO.

RONTGEN RAY APPARATUS.

The Thomson Röntgen ray transformer shown in Fig. 1, is intended for use with alternating currents, and consists of a low-frequency transformer, a high-frequency transformer and a condenser, all built into a substantial wooden box made to contain oil, and furnished in a handsome manner. The discharge terminals and the spark gap are brought up on the outside and at the upper portion of the box, the spark gap being covered. In constructing the transformers and condenser, great attention has been paid by the makers to insulation. The heavy insulation of the coils, together with that afforded by the oil with which the box is filled, afford assurance on this vital point.

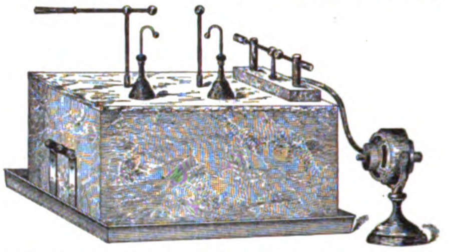


FIG. 1.—THOMSON RÖNTGEN RAY TRANSFORMER.

The only other accessories necessary to complete this set of exciting apparatus are a small choking coil regulator, by means of which any necessary regulation is accomplished; and a small motor, shown in the cut, connected with a jet placed immediately in the spark gap, by means of which the spark is ruptured with rapidity and certainty.

The length of the working spark is five inches, and with the large quantity and high frequency developed, the most elaborate and complete examinations of the opaque parts of the human body can be made, and even the movement of the heart observed, when a proper Röntgen ray tube is employed. The apparatus is particularly adapted for hospitals, and for physicians and surgeons who can have the use of an alternating current. With it the time of exposure for radiographs is reduced to a minimum, in the case of hands and arms only a few seconds being necessary.

This set cannot be used with batteries or on a direct current lighting circuit, except in connection with a rotary transformer or dynamotor which will convert direct into alternating currents.

In Fig. 2 is shown a Thomson universal double focus tube for use with the above or any other Röntgen ray apparatus. A valuable feature of this tube is an auxilary tube containing a chemical substance by means of which the proper degree of vacuum can be maintained. It is well known by all who have experimented with the production of Röntgen rays, that the vacuum in all tubes will gradually rise with continued use until the air has become so rarefied that the electrical discharge cannot be passed through it. When the tube arrives at this condition it becomes useless and, in order to obtain further service from it, it has been necessary to have it re-exhausted.

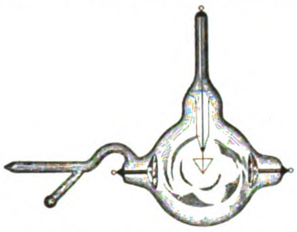


FIG. 2.—THOMSON DOUBLE-FOCUS RÖNTGEN RAY TUBE.

With the adjustable vacuum feature above referred to, this re-exhaustion is unnecessary, as by the simple application of a little heat to the small auxiliary tube, vapor is discharged from the chemical substance contained therein, which, flowing into the large tube, brings down the vacuum again to the proper point, thus prolonging the life of the tube indefinitely.

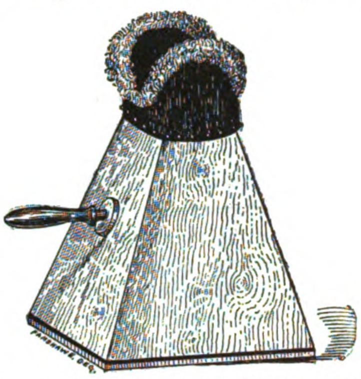


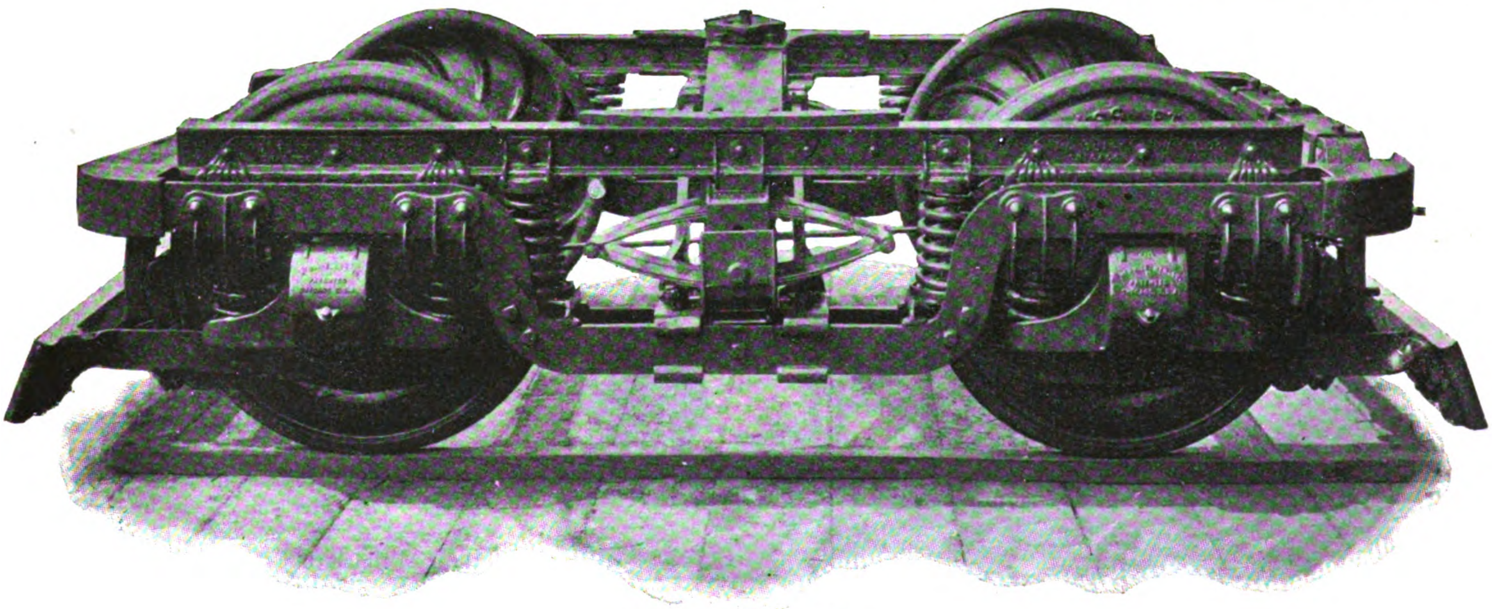
FIG. 3.—RÖNTGEN RAY FLUOROSCOPE.

The fluoroscope shown in Fig. 3 consists of a tapering box, at one end of which is placed a screen, 7 ins. × 8 ins. in size, containing upon its interior surface crystals of tungstate of calcium or other material that will fluoresce under the influence of Röntgen rays. At the other end is a flexible opening made to fit the upper part of the face of the observer so that the light will be excluded while the apparatus is in use. A handle is provided for convenience in holding the apparatus.

The above described apparatus is made by The Edison Decorative & Miniature Lamp Department, General Electric Company, Harrison, N. J.

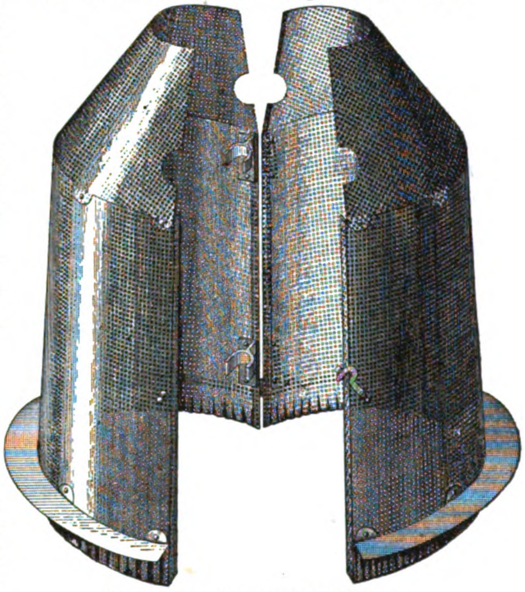
NEW MCGUIRE TRUCK.

The McGuire Manufacturing Company, of Chicago, has during the past year brought out a new pivotal motor truck, illustrated in the accompanying cut. This truck, as will be seen from the engraving, has an arrangement of springs corresponding in most respects to a modern passenger coach truck; in addition it has interposed springs between the axle journal boxes and the frame, which take the place of the ordinary equalizing bars, thereby so improving the riding of the car as to equal the best palace cars having twelve wheels instead of eight as these cars have. A novel method of mounting the truck frame on the elliptic springs has been introduced, which, while permitting an easy side motion, utilizes part of the elastic force of these springs to retain the truck frame always in a central position in relation to the car wheels. The brakes are hung below and independent of the car springs, preventing all clattering and kicking and variation in adjustment due to varying loads. The equalizer frame constitutes an independent motor or locomotive frame, and the manufacturers believe that the truck complete is as near a perfect combination of a locomotive and passenger coach truck as could be imagined. In service, both the locomotive and passenger coach truck features show up plainly, and it is said the results are all that could be desired.


NEW MCGUIRE TRUCK.

ARC LAMP SPARK ARRESTER.

The arc lamp spark arrester shown herewith is manufactured of perforated sheet steel, neatly japanned. The body, or main part of the device, has secured to it a rim of sheet iron a short distance from the lower edge, which rim rests upon the top of the


ARC LAMP SPARK ARRESTER.

lamp globe. The cone-shaped top is riveted to the body of the arrester, thus not only making it rigid, but also increasing its usefulness as a safeguard against wandering sparks.

The arrester is made in two parts, fastened by hinges at the back, which allows it to be opened or closed easily when placing it on or removing it from the lamp. It is made in three different styles—for wide frame arc lamps, for narrow frame arc lamps, and for the Western Electric constant-potential arc lamps.

For both the narrow and wide frame arc lamps, the total height is ten inches; the distance from the top of the arrester to the iron rim is nine inches, one inch of the arrester extending within the lamp globe. The diameter of the base is 7½ ins.

The difference between the arresters for wide frame and narrow frame lamps consists in the method by which they are fastened to the rods of the lamp frame. The illustration shows the arrester for a narrow frame lamp where the frame is of such a dimension as to necessitate having the rods within the lamp globe.

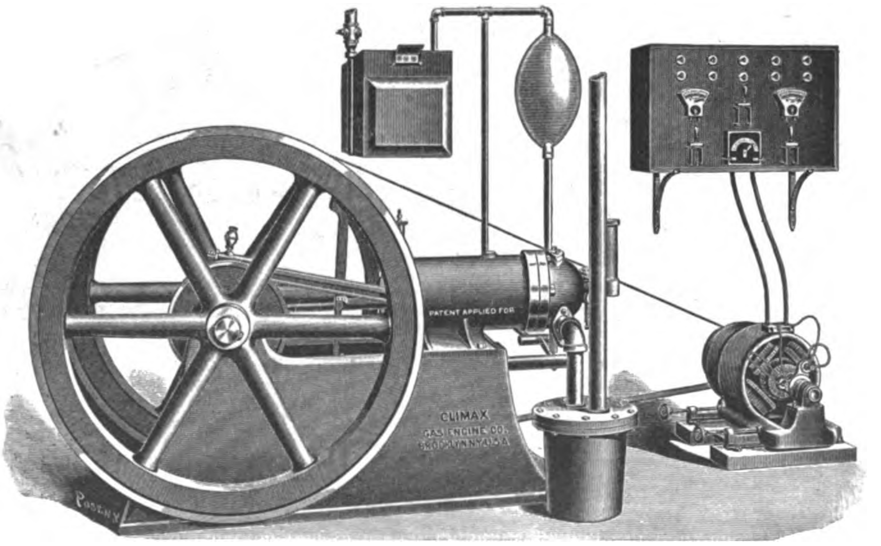
When the arresters are for wide frame lamps, the clamps are fastened at the back near the hinge, and extend outward instead of inward, as shown in the cut. There are no small openings or holes cut in the cone top, as the rods of the frame do not touch or enter the arrester.

The spark arrester designed for the Western Electric constant-potential lamp is but 8½ ins. in total height, and the iron rim is ½ in. from the bottom. The clamps are inside, as shown in the illustration. The diameter of the base is 7½ ins.

The arrester described is manufactured by the Western Electric Company, of Chicago and New York.

CLIMAX GAS ENGINE.

The economy that may be obtained in electric lighting from a gas engine isolated installation is well exemplified by an exhibition plant now running at 31 Fulton Street, Brooklyn. In this case, too, the visitor is accorded the unusual privilege of determining for himself the necessary data by inspection of the several meters connected, which are all in open view.


PATENT APPLIED FOR
CLIMAX
GAS ENGINE CO.
BROOKLYN N.Y.

CLIMAX GAS ENGINE.

The plant consists of a 12.2-I. HP Climax gas engine belted to a 5-KW Churchward four-pole dynamo, the combination being illustrated in the accompanying engraving.

The engine is of the usual "Otto cycle" type, there being one explosion to two revolutions. The hot tube method of ignition is employed. The valve gear is of extreme simplicity and exposed to view. It consists of a horizontal shaft receiving motion from a gear on the engine shaft, and having on it three cams; one of these cams works the exhaust valve, another the air valve and the third a Corliss type of trip gear for operating the gas valve. The release of the latter is very sharp, and is so timed by an inertia governor as to maintain a uniform speed of engine.

The indicator card taken from this engine is of unusually smooth appearance for a gas-engine card. The exhaust of the engine is remarkably uniform, as indicated not only by the ear, but by inspection of the vibrations of the needle of a voltmeter. The manufacturers ascribe the smooth and uniform working of the engine to the proper proportioning of passages and valves and the design of valve gear, whereby perfect combustion and absolute regularity of ignition are obtained.

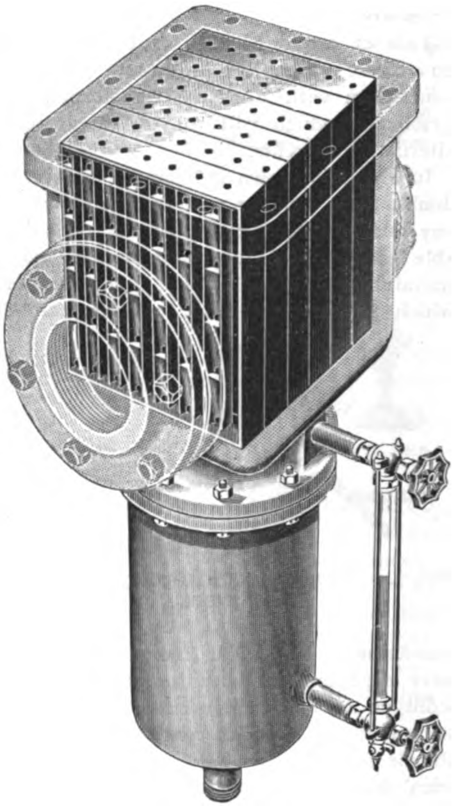
A gas meter by the engine and an ammeter and voltmeter on a switchboard near by, enable the visitor to make his own calculations as to efficiency, and the readings of the latter instrument may be checked by means of a bank of 3½-watt "Imperial" incandescent lamps, on the premises.

During a visit by the writer, the gas meter showed a regular consumption of gas at the rate of 180 cu. ft. per hour. During the same time the voltmeter read 110 and the ammeter 35, giving an electrical output of 3850 watts; 71 16-CP lamps were in circuit, thus showing 54 watts per lamp. At $1 per thousand cubic feet of gas, the cost of gas per lamp is almost exactly ¼ cent per lamp hour, or one fourth the usual central station charge. Another comparison may be made with the cost of burning the gas direct from jets. The 180 cu. ft. would thus supply 36 five-foot, 16-CP gas jets, so that twice as much light is given by transforming the energy of the gas into electricity as if the gas were burned direct from jets.

The above plant is being exhibited at the warerooms of the Climax Gas Engine Company, 31 Fulton Street, Brooklyn.

STEAM AND OIL SEPARATOR.

The Bundy separator illustrated in the accompanying cut consists of a nest of a number of upright baffle plates placed directly in the steam passage way and at right angles to it, and having a receiver underneath. In operation advantage is taken of the natural tendency of water and oil to cling to any obstructing surface.



BUNDY STEAM AND OIL SEPARATOR.

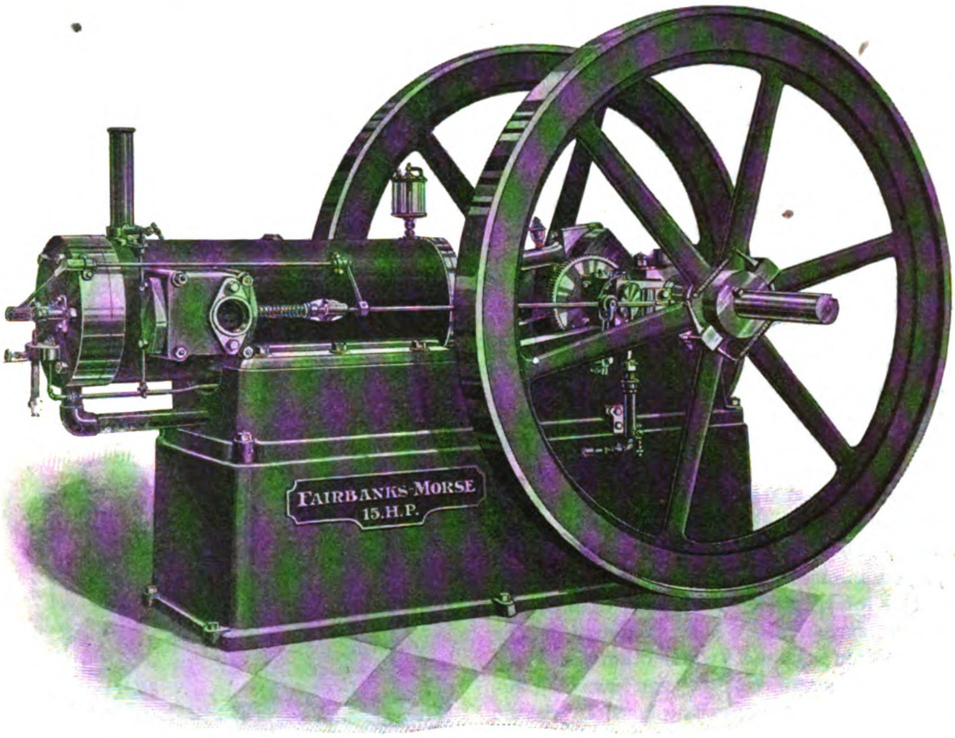
The steam strikes the flat front of each upright baffle, which have a series of receding hollows, sloping downward and terminating in a small hole leading to the main artery or channel for the safe conduct of the water or oil to the receiver.

Immediately back of the space in front of the baffle plate comes the upright of the second plate, and so on through all of them. The plates are set staggered to each other, with, however, plenty of area for the steam to pass through to the engine. The main advantage claimed by the makers of the Bundy separator is that when once separated from the steam, there is no possible chance for the water or oil to be again picked up by the steam. The water and oil are immediately conveyed to the enclosed passage way, through which they flow downward into the receiver. The baffle plates do not in any way diminish the pressure of the steam nor cause any wire-drawing.

This separator is made by the A. A. Griffing Iron Company, 66 Centre Street, New York.

MORSE-FAIRBANKS GAS AND GASOLINE ENGINE.

Fairbanks, Morse & Company, of Chicago, who are well known as manufacturers of gas and gasoline engines, have developed a special design of engine adapted for direct belting to dynamos, and are now placing on the market a single cylinder type, illustrated in the accompanying cut, working on the four-cycle principle, which satisfactorily drives a dynamo with the minimum amount of variation in voltage necessary to produce a commercially satisfactory light.



MORSE-FAIRBANKS GAS AND GASOLINE ENGINE.

The variation in revolutions is claimed to be less than one per cent. As the engine is not of excessive high speed, it is not of short life, which has been the case with other engines designed for this purpose. It is built exceptionally heavy, being fitted with an extra shaft, larger bearings; in fact, added to at all points necessary to make it long lived and amply strong so that it will not be subjected to excessive wear or liable to breakdowns, which with some engines have been such a prolific source of annoyance.

The engine does not differ materially in its mechanical movements from the standard engines of the same manufacturers; it is, however, fitted with a more sensitive governor, which is attached to the flywheel in the same manner as the governor of the standard type, and the admission of gas or gasoline is similarly controlled. Sight feed oilers are used on all running parts with oil shields to protect the throwing of oil.

The engine is self contained on a one-piece base, so that it does not require an extensive foundation, and is especially balanced so that there is no jar or jerk as has been so common in some other types of gas engines. It is provided with a patent self-starting device which enables one man to start engines ranging from 2 to 100 HP without other assistance. The engines are furnished with electric or hot tube igniters, or both if desired.

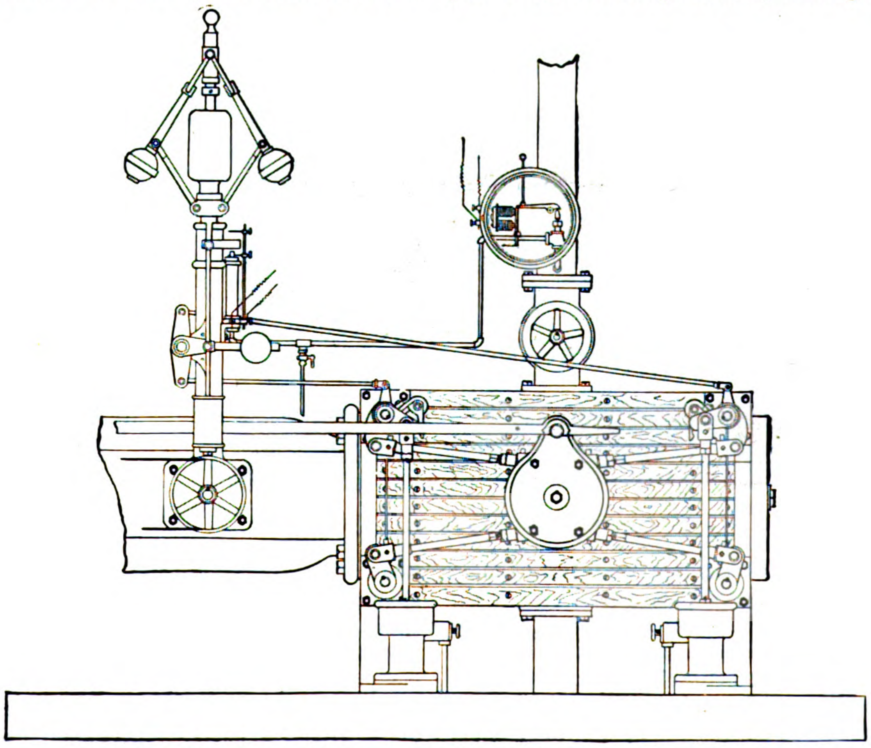
The engines are built to operate with gas or gasoline. When gasoline is used for fuel, the supply tank is located outside of the building and underground. The oil is supplied to the engine by means of a small pump operated by the engine. Only a small quantity of oil is retained in the engine, the surplus being returned by gravity to the supply tank outside of the building. The gasoline does not at any time come in contact with the atmosphere, but is kept confined until it is admitted to the cylinder, making it impossible to meet with an accident which would result in an explosion outside of the engine.

Gasoline is perhaps the cheapest fuel with which to operate the gas engine, except in locations where natural gas is accessible. In this case, natural gas at fifty cents per thousand cubic feet would be equal to gasoline at ten cents per gallon. The cost of an hourly electric horse power would be less than one cent on either of the above mentioned fuels.

Fairbanks, Morse & Company, have given special attention to engines for driving dynamos, from 20 HP upward, and have installed in the past year several plants of over 20 HP.

ELECTRIC ENGINE STOP.

The electric engine stop illustrated herewith consists of three essential parts: A steam cylinder for raising the governor balls, a valve for admitting steam to this cylinder and an electromagnet for releasing the valve. The valve admitting steam to operate the mechanism is normally held closed by a lever resting upon the armature of the electromagnet. When it is desired to stop the engine which the device controls, an electrical circuit is closed by pressing a button, when the resultant movement of the armature releases the lever; this in turn releases the valve, allowing the steam to pass into the cylinder and to force the piston upwards. In the upward motion a clamp attached to the side rod is engaged, thus raising the governor balls to their highest position and preventing the grab hooks from opening the main valves. There is also a speed limit attachment on the governor, consisting of two adjustable points so placed that when the speed of the engine either increases above, or diminishes below, a desired point, the circuit is closed and the engine is stopped. The electrical circuit can be extended so as to cover every part of the workshop served by the engine, and the number of stop buttons that may be installed is unlimited.



CORLISS ENGINE FITTED WITH SPRINGFIELD ELECTRIC STOP.

This stop is manufactured by the Springfield Engine Stop Company, 291 Main Street, Springfield, Mass.

STREET RAILWAY AIR BRAKES.

In Fig. 1 we illustrate the latest type of gearless electric motor-compressor, made by the Standard Air-Brake Company. This company, which from the start has been the leader in street railway air-braking, long since discarded open type compressors, having found that for lasting service under street cars, with the severe conditions existing, it was preferable to have all exposed parts of the air-brake encased. Particular attention, therefore, has been paid to this feature, in order that the various parts might be dust and water-proof. It will be noticed that the machine is iron clad, and that there is no chance for dirt or water to accumulate. It is furnished in capacities ranging from ½ to 2 HP. All moving parts work in oil. A very important feature is the small space the machine occupies. The dimensions of the 1-HP type do not exceed 12 ins. high × 15 ins. wide × 28 ins. long. Thus it is possible to install the outfit under an ordinary car seat, instead of having to mount it on the platform, where, at times, it might be in the way.

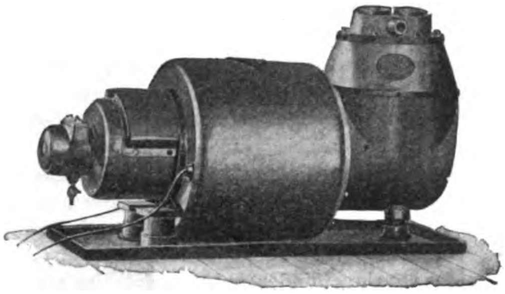


FIG. 1.—INDEPENDENT MOTOR COMPRESSOR.

The running of this motor-compressor for thirty seconds will compress enough air to suffice for a half dozen stops. It will be seen from this that the motor-compressor is idle most of the time, thus securing long life of the apparatus. The vibration is taken up by cushions which prevents transmission of noise to the car; the motor-compressor runs very quietly, the noise being scarcely perceptible. The compactness of this apparatus makes it practicable to suspend it under the floor of the car, in case it should not be desirable to put it on the platform or under a car seat. It can safely travel in such exposed position, without suffering injury or becoming inoperative, a feature, the manufacturers state, which is found only in the "Standard" apparatus. Oiling is necessary only at infrequent intervals. All parts are made to gauge, and replacements, should such become necessary, may be easily and economically effected. The "Standard" motor-compressor differs from other types in that it is direct coupled, thus avoiding expensive gear replacements. Its greatest advantage, however, is the entire avoidance of the noise and rattle inseparable from the use of gears in such small machines.

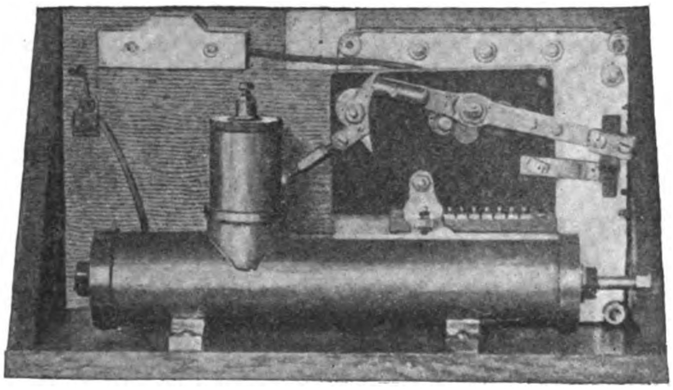


FIG. 2.—CONTROLLING APPARATUS.

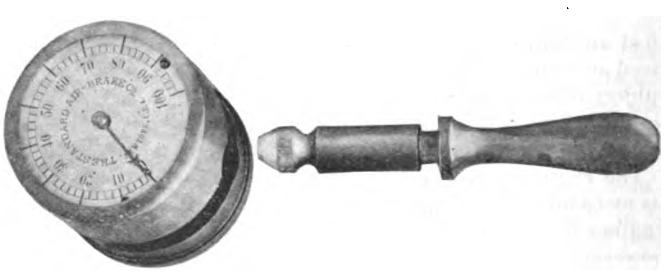


FIG. 3.—CONTROLLING HANDLE.

Realizing the undesirability of relying upon motormen to throw on and off the current for operating air-brake motor-compressors, the company has for some time gone very carefully into the building of automatic controlling apparatus which would relieve motormen from all such responsibility. The result of its labors is shown in the device illustrated in Fig. 2. This automatic controlling apparatus, which has been patented here and abroad, is the first of its kind in the field. It has been designed to meet every contingency, in order that there may not, at any time, be anything to interfere with its rapid and reliable operation. The special features claimed are as follows:

Perfect automatic action in starting and stopping, the motor starting as easily as if operated by hand. Resistance automatically placed in circuit with the motor when current is interrupted. The speed of motor is never excessive. When pressure in the reservoir is released (when otherwise ordinarily the motor would "run away"), resistance is automatically placed in circuit and controls speed; conversely, when the motor-compressor is started with the reservoirs empty, resistance is gradually removed from the circuit as pressure increases. When current is interrupted by opening of the circuit-breakers, resistance is immediately introduced into the motor circuit; the same action occurs if the trolley flies off or the motorman removes the trolley on changing from one end of car to the other.

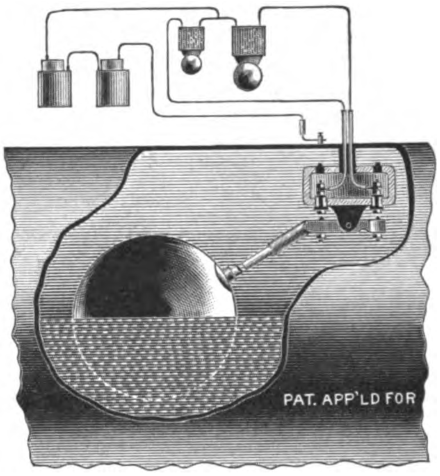
This type, which is now on the market, makes it possible to equip any electric car, train or locomotive, no matter whether there is any free axle space available or not. Where, however, there is a free axle space alongside of the motors, of from 6 ins. upwards, the company furnishes its well known types of single and double-acting compressors (driven either directly or indirectly from the car axle), of which hundreds are in successful operation here and abroad.

A unique feature of its system is the interlocking controlling handle, shown in Fig. 3. By using this handle, when motormen shift from one end of car to the other, a mistake becomes utterly impossible. The handle must be inserted in one particular place and can only be withdrawn from that place. When inserted, it makes the air-brake operative from that end of the car. When withdrawn, it securely locks the controlling valve at that end, leaving the other end locked until again opened by the insertion of the handle.

It will be observed that the pressure gauge is mounted on top of the controlling apparatus, where the dial must be constantly be seen. It is not possible for motormen to be ignorant of the air pressure available. The pressure vane is not double-headed, but is made in such shape as to make readings absolutely certain.

HIGH AND LOW WATER ALARM.

The parts of the alarm illustrated in the accompanying cut, consist of a float attached to a lever, on the end of which is a contact make-and-break bar having two contact screws. This bar is suspended on a hanger, on the lower side of which are two adjustable contact screws and two contact pins extending through the casing.



HIGH AND LOW WATER ALARM.

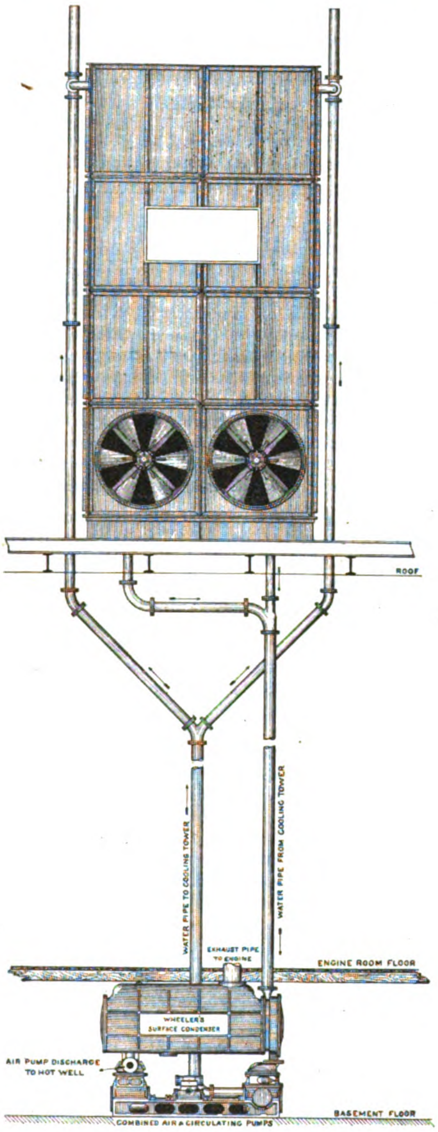
The operation is as follows: When the water in the boiler falls, one of the contact screws is brought in electrical contact with one of the pins, completing the circuit and causing a gong to sound. In the event of the water rising above the normal, the action is reversed and another gong sounded. When the water is at the proper level all contacts are broken. All the contact points are made of platinum, which is not corroded by steam.

Only one hole is necessary in the boiler to attach the alarm. Any number of signals may be connected in the circuit; for instance, the engine and boiler room or the manager's office may each contain gongs. Test buttons may be used to test the circuit when desired.

F. & F. H. Engelhardt, Springfield, Mass., are the inventors of the above described alarm.

BARNARD WATER-COOLING TOWER.

The successful installation of several Barnard water-cooling towers, illustrated in the accompanying engraving, under widely different conditions of use and in different localities, seems to offer evidence that these towers will enable a good condenser to maintain a degree of vacuum fully equal to that obtained by using water from natural sources; consequently, all steam power plants may be operated condensing. An electric station recently equipped with this apparatus is the Twelfth Street station of the Edison Electric Illuminating Company, of New York. The condensing apparatus includes a Wheeler standard surface condenser, mounted upon the air and circulating pumps placed in the basement, and a Barnard water-cooling tower located on the roof, which is some seventy feet above the condenser. The up discharge pipe from the top of the condenser conveys the hot water to the top of the tower, and the pipe from the bottom of the tower conducts the cooled water down to and through the circulating pump and condenser to the up pipe. This water is kept in continuous circulation through the channels above described, and is sufficiently cooled in its transit through the tower to enable the condenser to easily maintain twenty-five inches vacuum.


ROOF
WATER PIPE TO COOLING TOWER
WATER PIPE FROM COOLING TOWER
EXHAUST PIPE TO ENGINE
ENGINE ROOM FLOOR
WHEELER'S SURFACE CONDENSER
AIR PUMP DISCHARGE TO HOT WELL
BASEMENT FLOOR
COMBINED AIR & CIRCULATING PUMPS

WATER COOLING TOWER.

On Apr. 2, 1896, a continuous six-hour test of a De Laval steam turbine was made, with an average load of 1402 amperes. Throughout the test the vacuum gauge ranged from 25 ins. to 26 ins., averaging 25.6 ins.; and on Sept. 2 a full load was carried for five hours, with an average load of 3628 amperes (about 732 I. HP), the vacuum averaging over 25 ins. It will also be of interest to state that the exhaust steam averaged 13,535 lbs. per hour, and that the losses by evaporation, etc., were only three per cent. of the circulating water, and did not exceed eight per cent. of the boiler feedwater when the engines were working condensing.

The Barnard cooling towers are continuously efficient, as they are subjected to no wear or oxidation, the superficial surfaces being steel wire cloth (galvanized after weaving), made in mats and suspended in a vertical position, properly placed. The hot water from the condenser is evenly subdivided and distributed over the upper edges of the mats, uniformly flowing over and through them, thus compelling every square foot of the mats to do a proportionate amount of work. The space occupied by the tower is small, and the power required to operate is estimated at from two per cent. to possibly five per cent. of that of the main engines, according to conditions.

The Barnard water-tower, including its air and circulating pumps, is made by the Wheeler Condenser & Engineering Company, 39 Cortlandt Street, New York.

DOUBLE-DECKED STREET CAR.

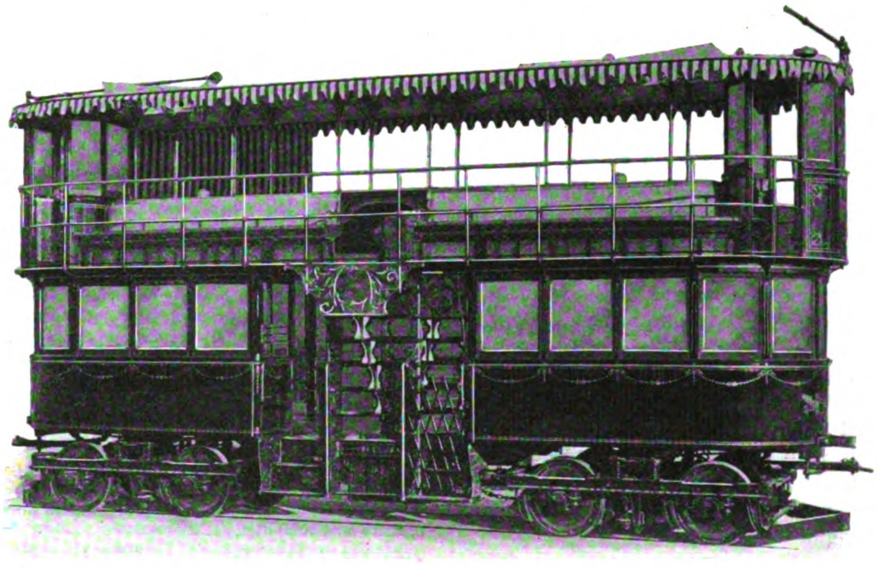
Mr. Charles F. Pullman, recently of the Pullman Palace Car Company, has designed a new form of street railway car, shown in the accompanying illustration, which contains a number of new and interesting features. As will be seen, the car is double-decked, and of the center vestibule type. The body has a steel structure, and the same material is employed in the roof, floor and sides, giving a lighter and stronger car, lessening the cost, reducing the height, and so lowering the floor of the car that there is only a single step in entering and leaving.

There is a double entrance in the middle of the body on each side, so that whichever way a car may be running two entrances are always available on the safe side for passengers to enter or leave it. Entrances to each end of the car, protected by sliding doors, open from the vestibule, and four commodious stairways lead to the upper deck. These stairways, two on each side, are in the inside of the car, in the center vestibule, and are perfectly protected, thus making them not only comfortable and convenient, but safe means for reaching and leaving the upper deck, and especially suitable for ladies and children.

As will be seen from the illustration, loading and unloading through the central doorways can be done in about half the time it takes to load or unload a car with end entrances, as passengers have only to go half the length in order to get out, and the same on entering.

As these cars carry double the load of an ordinary car, they will be especially valuable for large cities, where track space in the streets is crowded, as each car will do the work of two ordinary cars, while occupying only half the length of rail space.

This new car gives an opportunity to street railway managers to popularize their service, for its adoption, aside from other advantages, would undoubtedly be highly appreciated by the public on account of the double-deck feature, which all visitors to Europe so highly commend—a seat "à l'impériale" being there the choice of most passengers.

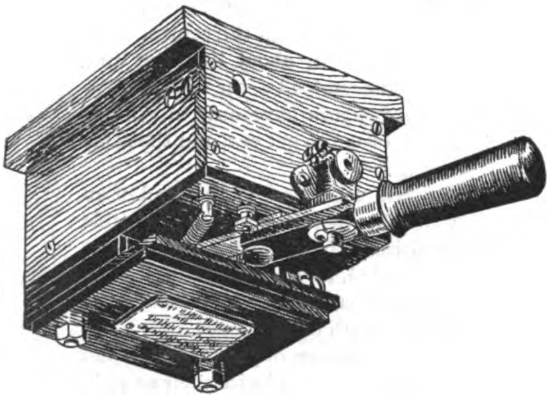


DOUBLE-DECKED VESTIBULE CAR.

AUTOMATIC CIRCUIT BREAKERS FOR CARS.

To avoid the delay necessitated in replacing fuses, the General Electric Company has designed an arrangement whereby the main motor switch is made an automatic circuit breaker instantaneously operating and easily reset. The "M" circuit breaker, as the device is called, in appearance resembles the main motor switch and in every way answers the purpose of one. It is intended to be placed in the same position under the car hood. The handle is so arranged that the breaker may be opened and closed by hand in the same way as the standard main motor switch. The device is provided with a magnetic blow-out and can thus break the severest short circuits without injury to itself. It opens the circuit instantaneously, and the ability to close the circuit immediately after it has opened, thereby avoiding delay to the car, will be at once appreciated.

The circuit breaker is so constructed that an automatic counter may, when desired, be introduced into it, in such manner as to preclude any tampering with it by the motorman. This registers every time the circuit breaker opens automatically, and affords an excellent method of detecting the improper handling of the cars. It gives to the inspector a means of discovering those motormen who have turned on the current too suddenly, calling for an excessive amount of current.



AUTOMATIC CIRCUIT BREAKER FOR CARS.

The circuit breaker is adjustable. By a simple movement of the calibrating spring, the breaker may be adjusted to open at any predetermined amount of current within a certain range. The device is manufactured for 75-150 amperes and 150-250 amperes, the first figure representing the lowest tripping point, the second the maximum carrying capacity for steady loads. The adjustment may, however, be made to break the circuit at currents considerably higher than the maximum carrying capacity. By the use of this device, considerable injury may be spared motors and other car apparatus, to which, with fuses, they are subject on account of the interval of time between the commencement of a heavy current, and the melting of the fuse.

EDISON X-RAY APPARATUS.

We learn that the Edison Manufacturing Company is placing on the market a full line of X-ray apparatus, which has been perfected under Mr. Edison's personal supervision. It will handle a range of outfits operated by battery power, and also the special instantaneous air-brake-wheel apparatus to run on the 120-volt direct current, which Mr. Edison exhibited at the recent Electrical Exposition, in New York, and to which considerable improvements have been added.

Up to the present time, no Edison X-ray apparatus has been placed on the market, as it was Mr. Edison's wish to bring this apparatus to a high degree of perfection before placing it before the public. The Edison laboratory has at present a staff of men employed exclusively in making Edison X-ray focus tubes, under the personal direction of Mr. Edison.

PERSONAL.

Mr. M. M. Wood, of Chicago, has accepted a position with the Ohio Brass Company, of Mansfield, O., as electrical engineer.

Mr. T. F. Grover, superintendent of the Milwaukee & Wauwatosa Electric Company, has been appointed general manager of the Fond du Lac (Wis.) Electric Light & Power Company, and assumed his new duties on Oct. 1.

Mr. Thos. A. Hurley, of Holmes, Booth & Hayden, will sail Oct. 17, for Europe, where he will remain some months in order to recuperate his health. Mr. Hurley will carry with him the hearty wishes of an unusually extended circle of friends who hope for a rapid recovery of his health.

Mr. E. J. Wessels, general manager of the Standard Air-Brake Company, is confident that the day is near when the use of air-brakes on electric cars will be as universal as on steam passenger cars. To his persistent energy in bringing and keeping the subject before electric railway people, not only in this country but abroad, is due the notable headway already made in this direction. The readers of the advertisements of the Standard Air-Brake Company will not be surprised to learn that *Printer's Ink* ranks Mr. Wessels among the most talented writers of advertising literature in the United States.

Mr. Wm. C. Camp, has purchased an interest in the Metropolitan Electric Company, of Chicago, and is now its vice-president and treasurer. Mr. Camp is one of Chicago's enterprising young business men of marked ability and considerable experience. In addition to his interest in the Metropolitan company he is also one of the principal owners of the firm of Estey & Camp, the wel-known musical instrument manufacturers and dealers, and has been for some time its secretary and treasurer. Mr. Camp will retain his interest in that firm, but will devote his active energies to pushing the business of the Metropolitan company. As a successful composer of ballads Mr. Camp has also won considerable fame in the musical world. "To Her" and others being among those of recent date.

Mr. James Rich Steers, was married Oct. 7, at "Clover Nook," Scarsdale, N. Y., to Miss Mary Dolores Beales, daughter of Mrs. James A. G. Beales, and grand-daughter of the late Eugene Kelly. Mr. Steers has been connected with the electrical business for some years, starting with the Interior Conduit & Insulation Company, of New York, and is now the partner of Mr. A. K. Warren, of electrical repair fame, trading under the old name of "A. K. Warren & Company." Mr. Steers has also the distinction of being a nephew of Mr. James Steers, the builder of the celebrated racing yacht "America." He is a graduate of Columbia College and a sportsman of no small degree, and all will wish him success on his venture as a Benedict.

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NEW BOOKS.

Röntgen Rays and Phenomena of the Anode and Cathode. By Edward P. Thompson and Prof. William A. Anthony. New York: D. Van Nostrand Company. 190 pages, 105 illustrations. Price $1.50.

In 210 numbered paragraphs this book contain a vast amount of information concerning Röntgen rays and allied phenomena. The text consists principally of extracts from scientific and professional journals, both American and foreign. In a final chapter, Prof. W. A. Anthony gives a concise résumé concerning the general principles of radiant energy, and examines the hypotheses offered concerning Röntgen rays.

What is Electricity? By John Trowbridge. New York: D. Appleton and Company. 315 pages, 53 illustrations. Price $1.50.

While the answer given by Dr. Trowbridge to the question appearing on the title page of this volume—an answer occupying but ten lines in a volume of 315 pages—is far from being definite—in fact, could not be otherwise—yet to the reader who desires to become acquainted with the modern views concerning electricity, this book will be found one of absorbing interest. The book is written for popular reading (being one of the International Scientific Series) and contains the first treatment in a popular manner of Maxwell's great generalization, the electromagnetic theory of light.

Physical Units. By Magnus MacLean. New York: D. Van Nostrand Company. 147 pages, 6 illustrations. Price, $1.25.

The greater part of this useful little book is devoted to a discussion of physical units and the relations between them. Dimensional formulas are given in all cases, and their deduction explained. The more useful physical constants and relations are given in alphabetical order, following which is an appendix on the practical electrical units and their determination. The final pages contain 32 tables of physical constants, including tables of specific inductive capacity, conductivity and resistivity of copper, resistivities of various substances electro-chemical equivalents, etc.

The Dynamo:—How Made and How Used. By S. R. Bottone. London: Swan Sonnenschein & Company, Lim. 116 pages, 77 illustrations. Price, $1.00.

That this little book has entered into a ninth edition is evidence that it has been appreciated by readers. The contents originally appeared in the pages of the *English Mechanic*, and are intended to meet the demands of amateurs desiring to construct small dynamos. The latest edition contains a number of new sections treating more particularly of the errors into which the amateur is apt to fall. The constructions described are decidedly amateurish, but those who are not ambitious as to the mechanical appearance of their work, may find in this volume what guidance they need in the construction of simple though crude machines.

A Practical Handbook on the Care and Management of Gas Engines. By G. Lieckfield. Translated by G. Richmond. With instructions for running oil engines. New York: Spon & Chamberlain. 103 pages, 14 illustrations. Price, 75 cents.

The scope of this little volume is indicated by the translator who states that "In the limits allowed it it has only been possible to refer to the Otto gas engine and the Hornsby-Akroyd oil engine." The first chapter is devoted to the features to be observed in selecting and installing a gas engine, and the second chapter to a consideration of brakes and brake trials. Chapters III. and IV. give instructions for the running and correction of defects, the latter subject being treated under 19 heads. Chapter V. is on dangers and precautionary measures in handling gas engines, and the final chapter deals with gasoline and oil engines.

The Magnetic Circuit in Theory and Practice. By H. DuBois. Translated from the German by E. Atkinson. New York: Longmans, Green & Company. 362 pages, 94 illustrations. Price, $4.00.

This thorough treatise on the magnetic circuit is divided into two parts, of which the first treats of theory and the second, comprising about two-thirds of the contents, of applications. In the second part there are taken up in turn, the general properties of magnetic circuits, analogy of the magnetic and electrical circuits, the magnetic circuit of dynamos and motors and various kinds of electromagnets and transformers, and the determination of magnetic flux and induction. The work does not profess to be a practical manual, but is nevertheless valuable as a treatise in which are developed, in a logical and thorough manner, all of the principles which apply in practical work. A valuable feature is the many foot notes pointing out where further information may be obtained.

The Elements of Physics. A College Text-book. By Edward L. Nichols and William I. Franklin. Vol. II. Electricity and Magnetism. New York: The Macmillan Company. 272 pages, 228 illustrations. Price, $1.50.

This, the second of three volumes on the elements of physics, has for its subject electricity and magnetism. The book is written primarily for a college text-book, and while full use is made of the calculus no demand is made on the reader beyond that supplied by the ordinary elementary college mathematical courses. The first chapter is a mathematical introduction, and following are chapters on magnetism, current, resistance, E. M. F., condensers, and batteries. Chapter VI. is on measurement, and electrostatics is then treated in four chapters. The remaining chapters treat of magnetism in iron, induced E. M. F., thermo-electricity, some practical applications of electricity, units, the electromagnetic theory of light, and the mechanical conceptions of electricity and magnetism.

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TRADE PUBLICATIONS.

Dynamos for Isolated Lighting. The latest circular of the Walker Company is devoted to dynamos for isolated lighting, and contains a description in detail of the Walker type. All of the various details are illustrated, including armature winding, brush holder, etc.

Dynamo Brushes. Younglove & Gere, manufacturers of ventilated dynamo brushes, of 312 East Genesee Street, Syracuse, N. Y., have issued an eight-page descriptive circular, embodying their price list. Copies will be forwarded on receipt of name and address.

Dynamos and Motors. The Eddy Electric Manufacturing Company, has now in press a catalogue discribing and illustrating the various types of apparatus manufactured by it. The pamphlet, which will be a fine specimen of catalogue work, may be obtained by any of our readers upon application, which may be made at once.

Gas and Gasoline Engines. Fairbanks, Morse & Company, Beloit, Wis., have issued a well illustrated and printed catalogue of their gas and gasoline engines, which have now been before the public for sixteen years. The half-tone illustrations are admirable, and the descriptions are clear, full and to the point.

Storage Batteries. The Willard Electric & Battery Company, Cleveland, O, has issued a well illustrated and handsomely executed catalogue of the Willard storage battery. The battery is described and illustrated in detail by woodcut engravings, and in the final pages of the catalogue concise and practical directions, accompanied by diagrams, are given for the operation of a storage battery plant.

Elevators. Morse, Williams & Company, Frankford Avenue, Philadelphia, have issued an album of "Elevator Etchings," comprising 40 etchings printed on plate paper 9½ ins. × 13 ins. in size, and bound in artistic covers. A descriptive table of contents forms part of the publication. Among the elevators illustrated are a number run by electric motors.

Electrical Supplies. C. M. Turnquist, 214 South Clark Street, Chicago, Ill., in a new catalogue describes and illustrates a long list of electrical house and other supplies. Those interested in storage batteries will find in its pages some useful practical information concerning their selection and management. Among the batteries illustrated is a new form of plunge battery, the "Monarch," which is especially applicable to the operation of induction coils.

Electrical Supplies. The new catalogue of the Ziegler Electric Company, 141 Franklin Street, Boston, which contains no less than 198 large octavo pages, is one of the handsomest trade publications of the year. The fine quality of paper used brings out well the illustrations, of which there are almost five hundred. A great part of the catalogue is devoted to electric light supplies and apparatus, but house goods, measuring instruments, telegraph apparatus, etc., are also well represented.

Long Burning Arc Lamps. In a pamphlet with this title, the General Electric Company presents illustrations and descriptions of its new 100 and 150-hour arc lamps for use on direct-current incandescent circuits. Among the lamps shown is a marine type adapted for ship use, both in the hold and on deck. A calculation is given showing that with 100 lamps a saving of $804 per year may be made by replacing the ordinary arc lamp with the new 150-hour type.

Tools of Precision. In a catalogue and price list of machinists' tools, J. T. Slocomb & Company, 235 Eddy Street, Providence, R. I., illustrate a line of micrometer and other tools of precision for the workshop. The descriptions are extremely full, and together with the accompanying detail illustrations, may be said to form a technical treatise on the subject. This character is borne out by sections on "How to Keep a Micrometer in Order," "To Read a Micrometer," and several others.

Gas Engines. The Westinghouse Machine Company, Pittsburgh, Pa., in a handsome catalogue describes and illustrates the new Westinghouse gas engine. The excellent half-tone illustrations show the engine to be of the vertical type, resembling somewhat in appearance the steam engine of the same company, and marking a radical departure from the usual design of gas engine. The final pages of the catalogue contain finely executed illustrations of the several types of the Westinghouse steam engine.

Institute for Home Study. The new descriptive catalogue of the Institute for Home Study of Engineering contains 72 large octavo pages, in which the various courses which it teaches by mail are described in detail. A mechanical drawing of a connecting rod complete and an eccentric rod and strap printed on a large folding plate, is included. The prospectus of the electrical engineering course occupies no less than 12 pages, and the specimen electrical papers printed indicate that this branch is both thoroughly and practically taught.

Water in Cylinders. A little water in the cylinder seems like a trifling matter, and it is only when the volume increases to such an extent that the safety of the engine is threatened, that much attention is usually given the subject. It has been the experience of Hine & Robertson Company, 87 Cortlandt Street, New York, that the value of their Hine eliminator does not lie so much in the protection afforded, but from the fact that it dries the steam so thoroughly that lubrication may be effected with less oil, and longer life to the valves, seats, and cylinder walls is assured. They thoroughly treat on this subject in a little book which is sent on application.

Rontgen Ray Apparatus. A catalogue on "Röntgen Ray Apparatus" just issued by the Edison Decorative & Miniature Lamp Department of the General Electric Company, Harrison, N J., is perhaps the most practical contribution yet made to the subject of Röntgen rays. The 37 pages of matter contained in the pamphlet, together with the accompanying illustrations, will give a much better idea of the practical generation and utilization of the new form of radiation, than has, in most cases, been possible from reading the periodical literature on the subject, though even if it had been followed from the first announcement of Röntgen's discovery, to date.

Circuit Breakers and Switches. The Cutter Electrical & Manufacturing Company, 1112 Sansom Street, Philadelphia, has issued a new edition of it Circuit Breaker Catalogue, complete and accurate as to price and data to Oct. 1. This edition, which is known as the "Engineers' Edition" is made of a size which can be conveniently carried in the pocket, and is handsomely printed in two colors and artistically bound. In addition to the general information as to finish, price lists, rating and adjustment, there are cuts illustrating sections of the "I. T. E." circuit breaker, and templates showing location of holes in face of base for the various sizes, diagrams of connections, etc., etc. This should be a welcome addition to the literature on this subject and will undoubtedly be received with great favor by electricians for whom it is especially intended. A few pages are devoted to the important details of the well known C-S switch, so that the possessor of this catalogue has at hand for immediate reference a concise description of the output of the Cutter Company's factory, well known, as it is, for producing work which is electrically and mechanically of the highest standard of excellence. This catalogue will be sent to our readers on application.

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BUSINESS NEWS.

J. N. Bates & Company, Congress Street, Boston, Mass., has placed upon the market a new multipolar generator.

Arthur A. Brigham, 186 Devonshire Street, Boston, Mass., sole agent for the sale of the Kenyon cotton rope, is equipping several large drives throughout New England, and also in the South.

The Eddy Electric Manufacturing Company, Windsor, Conn., has been, and is, running full time. In fact, it is in receipt of orders, the filling of which will occupy the remaining months of the year.

The Ball Engine Company, Erie, Pa., has received some large orders for engines during the past week or two, both for foreign and domestic use, and the works will be kept running overtime with full force for months to come.

Chas. J. Bogue, 206 Centre Street, New York, has been very busy on armature and arc lamp work. A large stock of carbon holders for the different arc lighting systems has been also made up, thus enabling orders to be filled promptly in the future.

The Monash-Younker Company, of Chicago, has opened a branch office at 96 Centre Street, New York, for the sale of its steam specialties, of which a complete line will be carried in stock. L. P. Monash is manager of the office.

The Storey Motor & Tool Company, of Philadelphia, has moved its main office and factory to 214-226 Carter Street (below Chestnut Street), where with greatly increased facilities, made necessary by the rapid growth of its business, it will be able to promptly execute orders of any size.

The Springfield Asbestos Company, 275 Main Street, Springfield, Mass., is busy filling several large orders for its asbestos air cell, sectional covering. Wherever this covering has been used, it has without exception given satisfaction, and much of the work now being done by this company consists of duplicate orders.

A Correction. In our September issue it was inadverently stated that Messrs. Field & Hinchman, consulting engineers, had removed their offices to 1203-1204 Majestic Building, Chicago. The firm remains in Detroit; has removed from former quarters in that city to the building above named, which is located in Detroit and not Chicago.

The Watts Regulator Company, Lawrence, Mass., manufacturer of the Watts pressure regulator, and the Carlman damper regulator, have over 142 pressure regulators in the Pacific Mills, Lawrence, Mass., 94 in the Amoskeag Mills, Manchester, N. H.; 180 in the Calumet & Hecla Mining Company's plant, Michigan. and 300 in the Lowell Machine shops, Lowell, Mass.

The Ashton Valve Company, Boston, Mass., has received an order from the U. S. Government for a number of pump relief cylinder valves, to be used aboard the new torpedo boats now under construction. As in the past years, the Ashton Valve Company will, in December, issue a unique 1897 calendar, which will be mailed to its many friends and customers. To insure the receipt of this calendar, it will be well to have your name enrolled now.

The Silversmiths' and the Stewart Building are Chicago's two latest additions to its long list of towering office buildings. The Electric Appliance Company is particularly interested in the construction of these two mammoth buildings, as they are to be tubed throughout with Armorite iron-armored interior conduit, sold by the Electric Appliance Company, which claims that these two buildings, when completed, will have the finest interior conduit system in Chicago.

The American Stoker Company, of Dayton, O., has recently perfected a steam motor which is applied to each stoker, thus making each machine independent. This renders the work of installation very simple. It also renders the stoker practicable for use under marine boilers. This company is desirous of a general representation through engineering firms handling pumps, heaters and boiler room supplies and invites correspondence from interested parties.

Charles A. Schieren & Company, 45 Ferry Street, New York, report recent sales of leather belting, as follows: Two 72-in. three-ply leather belts for Municipal Electric Company, Brooklyn, N. Y.; two 56-in. three-ply leather belts for Manchester Electric Light Company, Manchester, N. H.; one 44-in. three-ply belt for Edison Electric Illuminating Company, Pottsville, Pa. Also a complete equipment for the Baltimore Sugar Refining Company, about $6,000 worth of leather belting.

The Typewriter Exchange, 1½ Barclay Street, New York City, established six years ago, has grown to such proportions that it was found necessary to open branches in different sections of the country. Besides the New York office, branches have been established at 156 Adams Street, Chicago; 38 Court Square, Boston, and 818 Wyandotte Street, Kansas City. This concern makes a specialty of selling typewriters far below the manufacturers' prices, and will also make terms upon the installment plan.

The Prouty Company, 328 Dearborn Street, Chicago, has recently perfected and put on the market a gasoline engine, which is especially adapted for service in small isolated lighting plants. It is claimed for this engine that it embraces all the latest and most important improvements and no offensive odors come from its use, the amount of cooling water required is very small, and that the construction of engine precludes any liabilities to accident under any circumstance. It is very simple in construction and it is claimed to be perfect in governing. Circulars and further information are gladly given by the manufacturers.

The Chicago Armature Company, 14 and 16 N. Canal Street, Chicago, has just reorganized with U. L. Swingley, president and treasurer; Martin L. Nelson, vice-president; John S. Parmele, manager; E. M. Parmele, secretary; and Wm. Wright, superintendent. With its new organization the company is now prepared to push its business harder than ever and will continue, as heretofore, to make a specialty of all kinds of repair work, including the making of commutators and armature winding for all systems. The company under its new management will also manufacture dynamos and motors. With its increased facilities, it is prepared to turn out all orders promptly and satisfactorily to its patrons.

The Columbia Stoker Company, Holyoke, Mass., is in receipt of a testimonial from the Springfield Brewing Company, as follows: "After giving your trial installation a three months' test we gave you the order to equip the remainder of our boilers with your Columbia stokers, which are now in successful operation. Previous to the installation of your stokers we contemplated adding one and possibly two more boilers to our battery, as it was impossible for us to generate sufficient steam to supply our demand; since your stokers are in operation we are pleased to inform you that we have an abundance of steam for all purposes, and at the same time have decreased our fuel consumption more than 25 per cent."

W. R. Brixey, 203 Broadway, has recently laid one of the longest, if not the longest, submarine telephone lines in this country, consisting of 3½ miles of Kerite cables. The cable, which was placed in position under the personal supervision of Mr. J. E. Ham, gives a private metallic circuit between Swinburne and Hoffman Islands in New York Bay, and connects them with the mainland, thus rendering instant communication possible between the islands and mainland, with the health physician's office, situated at Quarantine Station, Staten Island, with the Commissioner's office, situated in New York City, and with the State Government office, at Albany, New York, together with such points as might be deemed necessary to reach by long distance telephone throughout the state.

The Springfield Engine Stop Company, 273 Main Street, Springfield, Mass., has recently placed its electric engine stop in the following plants: Warwick Cycle Company, Springfield, Mass.; Lamb Manufacturing Company (A. G. Spalding & Brother), Chicopee Falls, Mass.; Hartford Carpet Company, Thompsonville, Conn.; New England Card & Paper Company, Springfield, Mass.; Holyoke Card & Paper Company, Brightwood, Mass.; George S. Colton, Easthampton, Mass.; Coulter & McKenzie Company, Bridgeport, Conn.; Worthy Paper Company, Mittineague, Mass.; The Orange Judd Publishing Company, Springfield, Mass.; Whitman Mills, New Bedford, Mass.; Potomska Mills, New Bedford, Mass.; Woonsocket Worsted Company, Woonsocket, R. I.; Eagle Mills, Woonsocket, R. I., and the Salts Fabric Company, Bridgeport, Conn.

The C. & C. Electric Company, 143 Liberty Street, New York, during the six months ending July 14, installed 654 HP of motors on the circuits of of the New York Edison Illuminating Company. The next highest of the twelve companies which installed motors on the same circuits during that period, has 163 HP to its credit, while the aggregate of the eleven competing companies does not greatly exceed the total of the C. & C. Company. Last year the showing of this company was 689 HP more than the greatest amount installed by any other company in twelve months. Computing for twelve months, it would have 962 HP more than the greatest amount installed by any other company, provided the present rate is maintained. The above records are taken from the reports of the Edison Company to its stockholders, of additions to the circuits during the periods stated.

Wm. Baragwanath & Son, 55 W. Division Street, Chicago, has recently sold and erected some very large heaters and purifiers. Among these orders which the firm is now engaged in filling, is one for three heaters, each of 2500 HP from the Chicago City Railway Company. Among other orders are the following: Kewanee Electric Light Company, Kewanee, Ill., one 100-HP heater; Howe Scale Company, Chicago, Ill., one 75-HP heater; Maywood Electric Light Company, Maywood, Ill., one 500-HP condenser; Washington Gas Light Company, Washington, D. C., one 225-HP heater; Great Northern Hotel and Theatre Building, Chicago, two 1500-HP heaters; Plankinton Park Company, Milwaukee; Wis., one 500-HP siphon condenser; Fraser & Chalmers, Chicago, one 100-HP heater; Waupun State Prison, Waupun, Wis., one 200-HP feed-water heater-Phoenix Brewing Company, Chicago, one 200-HP heater.

A. K. Warren & Company, have permanently located themselves at 451 and 453 Greenwich Street, New York, in the Trinity Building, opposite their temporary premises in Desbrosses Street in the shops lately occupied by the Garvin Machine Company. A. K. Warren and James Rich Steers, the proprietors have secured in these premises superior facilities for handling their peculiar business, as the shop, store and offices are all on one large ground floor, greatly facilitating the handling of heavy machinery, which, in repair, constitutes the main part of their business. Their contract department for maintaining electrical plants, has met with such success that they have had to engage further experienced help to keep up with the demand for inspections. A visit to their stores will repay all users of electrical machinery, as it will familiarize them with their complete system of handling emergency or breakdown work, which is now reduced to a science.

The Stromberg-Carlson Telephone Manufacturing Company, 172 Clinton Street, Chicago, continues to receive praise for the signal success of its latest telephone exchange, which was put in operation at South Bend., Ind., last month. The new exchange, which has a switchboard capacity for 600 subscribers, had 500 subscribers connected up on Sept. 1. Before the exchange was officially opened a political speech was transmitted to 100 subscribers from a "wigwam"; the Stromberg-Carlson Company put in a set of transmitters specially constructed by it for this service, and the result is thus described by a local newspaper: "The orator's words came over the wires clear and distinct, punctuated by the applause, laughter and shouts of the audience. At the close of the speech a babel of voices and sounds burdened the wires. There were congratulatory remarks, witty sallies, sarcastic digs at the enemy, laughter, coughs and the many other sounds incident to a large gathering of the genus homo.

The Electrical Exchange, Monadnock Block, Chicago, reports the following among recent shipments: One 200-lt. generator, to J. E. Duval, Lewsburg, N. C.; one 1300-lt. Slattery alternator, with exciter, instruments, etc., to the Terrell Light & Power Company, Terrell, Tex.; one 30-HP 500-volt Commercial motor to the Albart Lea Electric Company, Albart Lea, Minn.; one 200-lt. Davis generator, to the Q. & C. Company, Chicago Heights, Ill.; one 65-lt. Mather dynamo, to H. Rallen, Chicago; one 15-HP Detroit motor, to H. J. Rath, 50 N. Canal Street, Chicago; and apparatus for Billings, Mont., Irwin, Pa., Three Rivers, Mich., Riply, Tenn., Caro, Mich., Houlton, Me., Roslyn, Wash., Lewistown, Ill., Lake Butler, Fla., Lake City, Fla., Radford, Va., Bowling Green, Mo., Clinton, Ind., Fowler, Ind.; Lexington, Ky., Blue Island, Ill., Lowell, Mich., Massillon, O., Beatrice, Neb., Cardington, Pa., New Orleans, La., Fairburg, Neb., Columbia, S. C., Shushan, N. Y., etc.

Fairbanks, Morse & Company, Franklin and Monroe Streets, Chicago, call attention to the manner in which their wonderfully successful development of the gas and gasoline engine enables small manufacturers to avail themselves of a power which they can operate with an economy the best steam plant cannot approximate. This company, after sixteen years of research and development has long since passed the experimental stage, and now has thousands of engines in actual and successful operation, in some cases thirty or forty being in use by one firm. They are adapted to nearly all conditions of service for which the steam engine is used, but are entirely free from the objectionable features usually attending the use of steam. They require no boiler, no coal, no fire; they produce no smoke, soot or ashes, and are so entirely automatic as to practically require no skilled attendance. Many of the largest users of steam after trying this type of gas or gasoline engines have issued orders that no more steam engines shall be installed. These engines are specially adapted for running electric light plants, and the makers will gladly give further information in regard to their use in this connection.

The Standard Air-Brake Company points with pride to the fact that it is the only concern which builds street railway air-brakes that received diploma and medal at the World's Columbian Exposition. Since the last street railway convention the company has, among others, made contracts as follows: Pasadena & Los Angeles Electric Railway Company; Buffalo Railway Company; New South Wales Government Tramways, Australia; Germany; Switzerland; Brooklyn, N. Y.; Washington, D; C.; Worcester, Mass.; Akron, O.; Pullman Palace Car Company, Pullman, Ill.; Philadelphia, Pa.; Springfield, Mass.; St. Catharines, Ont.; Lorain, O.; etc. For obvious reasons, the company withholds more definite particulars. From a number of these places as many as from three to six repeat orders have come during the year. The business has increased enough during the year to compel the company to open a store-house in New York, where a stock of air-brakes and sundries is carried. The location, 254 Water Street, is central and convenien- for shipping. Since the company removed its fact tory from 11-23 South Jefferson Street, Chicago, and began manufacturing air-brakes within 5 miles from its headquarters, its business has steadily advanced.

K. McLennan & Company, Chicago, sole manufacturers of the standard Gale's commutator compound, report their sales during the past year more than double that of any previous year. The satisfaction with which the compound has met generally has exceeded their most sanguine expectations, and they are in receipt of enough testimonials unsolicted or, to use their own expression "to fill a volume". In response to numerous requests from their customers, the Fort Wayne Electric Corporation recently made a careful and exhaustive test, and the result, as expressed by them is as follows: "The application of Gale's commutator compound was attended with very satisfactory results. A slight sparking occurs at the moment of applying the compound; this, however, disappears instantly, and the commutator assumes a hard gloss. We recommend it to those having trouble with sparking, cutting of commutators, etc." The test was made under the personal supervision of Mr. Barnes. Mr. Isaacs of K. McLennan & Company states that this is but one of hundreds of similar tests, and with similar results. He will be at the street railway convention with sufficient samples so that every delegate may make a personal test, and convince himself of the merits of Gale's compound. In the meantime samples may be had on application to their office, Marqutte Building, Chicago.

Harvest Excursions.

In order to give everyone an opportunity to see the grand crops in the Western states and enable the intending settler to secure a home, the Chicago, Milwaukee & St. Paul Railway has arranged to run a series of harvest excursions to South and North Dakota, and to other states in the West, Northwest and Southwest on the following dates: Sept. 1, 15, 29 and Oct. 6 and 20, at the low rate of $2 more than ONE FARE for the round trip. Tickets will be good for return on any Tuesday or Friday within twenty-one days from date of sale. For rates time of trains and further details apply to any coupon ticket agent in the East or South, or address F. A. Miller, Assistant General Passenger agent, Chicago, Ill.

American Electrician.

Vol. VIII. New York, November, 1896. No. 7.

ISOLATED LIGHTING AND POWER PLANT AT HEARST HACIENDA, SUNOL, CAL.

BY W. F. C. HASSON.

THE attention of the traveler approaching San Francisco through the Livermore Valley will be attracted to a curious, castellated structure perched high on a hill in the vicinity of Sunol.

The building is in the style of the ancient haciendas of the rich Spaniards, who early settled in Mexico and Southern California, but it far exceeds its original prototypes in beauty and magnificence. It is the summer residence of Mrs. Phœbe Hearst, and is the product of the fertile imagination of Mr. A. C. Schweinfurth.

The building consists of a rectangular court enclosed on two sides by two-story, tile-roof buildings, and on the third by a monastic structure four stories in height. The cemented walks are covered with awnings, after the fashion of Mexico, and in the center of the court is a beautiful lawn rich with flowers and cooled by fountains.

The main building is connected by a colonnade to a second building of the Old Mission type, some two hundred feet away, which forms a studio, ball room and theatre. On the opposite side, other colonnades lead off to a variety of buildings, where are servants' quarters, laundries, engine houses, etc.

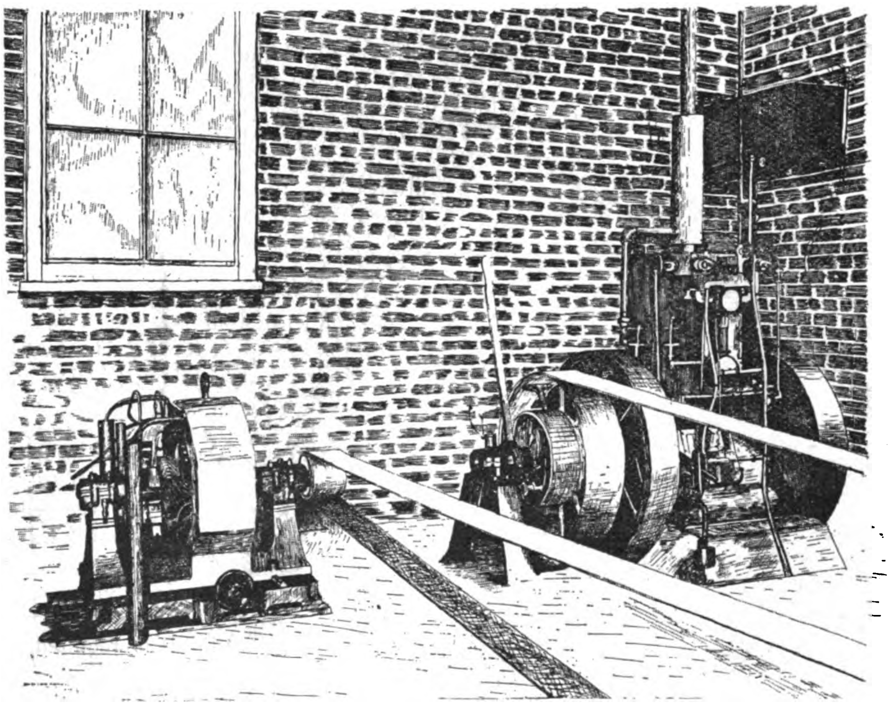


FIG. 3.—DYNAMO AND ENGINE ROOM.

Everything about the place is of an older time, except the electric light and power plant, which is of the most modern. The walls of the rooms are covered with the most valuable and beautiful tapestries, which would soon be destroyed by gas. It was desired to avoid the smoke incident to a steam engine plant, and it was further wished to avoid disturbing the calm peace of the country with the noise of machinery. To accomplish this an electric plant was installed.

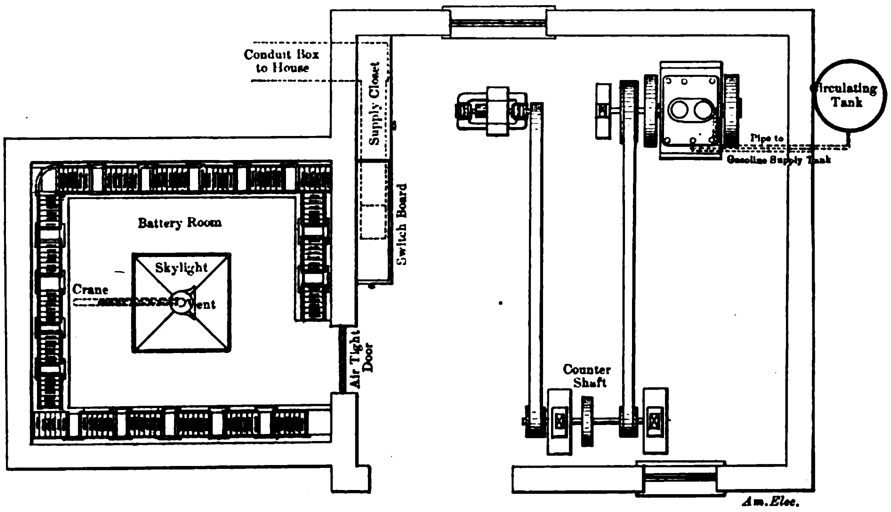


FIG. 1.—GENERATING PLANT.

The plant consists of a twin-cylinder gasoline engine, having a tested brake capacity of 22 HP. This is belted to a ratchet pulley on the countershaft, thence back to the dynamo, as shown in Fig. 1. The dynamo is a Western Electric machine, having a rated capacity of 9 KW.

The switchboard arrangements are as shown in Fig. 2, and Fig. 3 gives an interior view of the engine and dynamo room. Adjoining the dynamo room, is a storage battery room, where a storage battery, consisting of 60 "F 11" Chloride cells, is installed in two and three tiers. In the center of the room is a revolving crane, by which any cell may be lifted out of place for examination.

The main feeders are carried underground to the main building, where there is a second distributing switchboard for the various purposes of the buildings.

The engines are supplied with unusually heavy flywheels, and a third flywheel on the countershaft in connection with the ratchet pulley, prevents the speed of the dynamo being affected when there is any change in the amount of gas supplied the engine.

The switchboard is supplied with a double set of bus bars, so that current for lights may be supplied from the storage battery or from the dynamo direct. No difficulty is found in supplying a perfectly steady light directly from the dynamo.

After the plant was installed, it was found that the supply of water for the irrigation of the grounds was not sufficient, and a pumping plant, having a capacity of 5000 gals. per hour, to be pumped about 1300 ft., and elevated 310 ft., was added. This plant is operated by a motor supplied with current from the dynamo. When the plant was in full working order, it was found that by running from six to eight hours a day, sufficient current could be supplied from the storage batteries to meet the nightly demand, and sufficient water pumped to the storage tanks for irrigation purposes.

The contract for all the machinery was

closed on Apr. 15, 1896, and although everything but the gasoline engine had to be transported across the continent, the plant was in successful operation within sixty days.

The entire electric plant was installed by the California Electrical Works, of San Francisco, and that it was done with precision, is evinced by the fact that the plant has now been in operation for four months, without giving any trouble whatsoever.

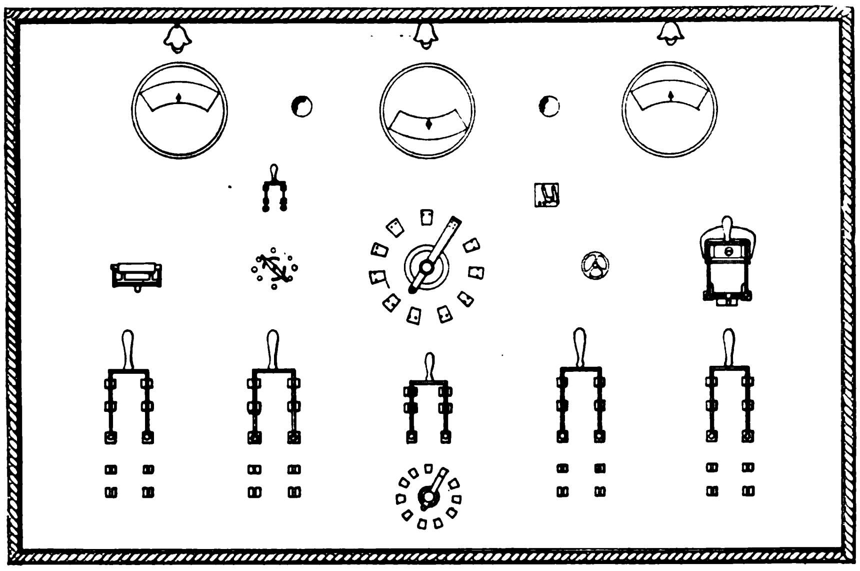


FIG. 2.—SWITCHBOARD ARRANGEMENT.

* * *

LIGHTING OF A COUNTRY RESIDENCE.

BY E. G. BERNARD.

That the owners of country residences have not more generally availed themselves of the advantages of electric lighting is perhaps not surprising when we consider how formidable the mechanical and electrical features of such a plant are likely to appear to them, and with what apprehension they are apt to view the result of its operation by the unskilled labor upon which they would have to depend.

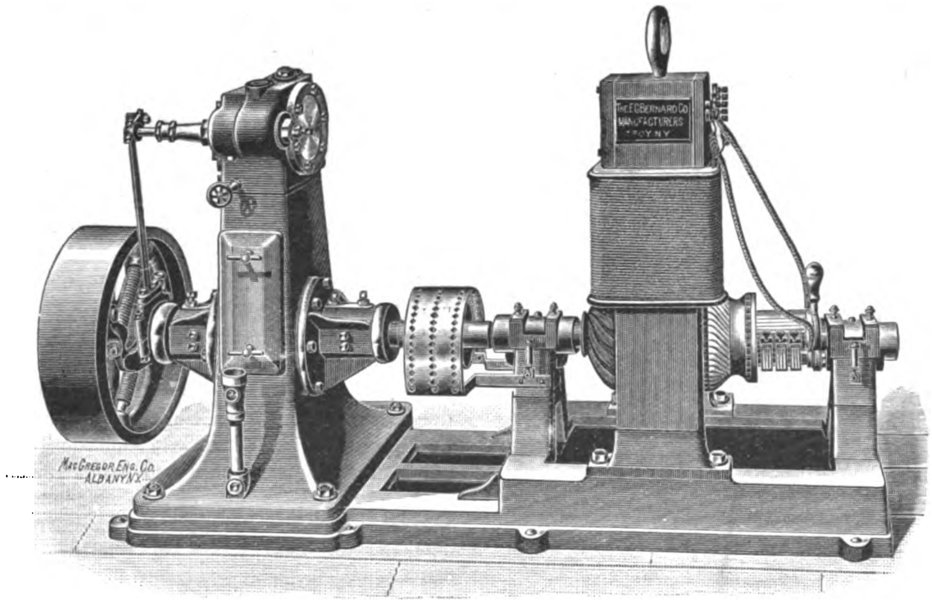

THE E.G. BERNARD CO.
MANUFACTURERS
TROY, N.Y.
MacGregor Eng. Co.
Albany N.Y.

FIG. 1.—DIRECT CONNECTED STORAGE BATTERY GENERATING UNIT.

In point of fact, at the present day an isolated electric light plant for a country residence can be so installed as to occupy little space, and be efficiently operated by almost any of the men kept about a place of any size, in some cases without notably interfering with their usual duties. A gardener or coachman is generally a man of sufficient intelligence to take direct charge of the plant; his presence may sometimes be necessary for a few moments at starting up or shutting down, but a boy or stable hand can attend to the plant while in operation, which need not be more than twice a week.

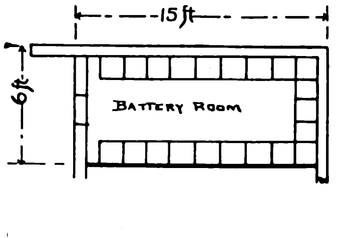


FIG. 2.—STORAGE BATTERY.

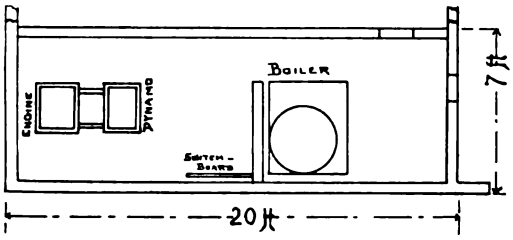


FIG. 3.—GENERATING PLANT.

To illustrate by a specific case, the following information is given relating to a plant installed about four years ago by the E. G. Bernard Company, of Troy, N. Y., at the summer residence of Mrs. Wm. Howard Hart, near Troy. The installation, which consists of boiler, engine, dynamo, storage battery and necessary wiring, has a capacity for 100 16-CP, 75-volt lamps, and is used for house, stable and grounds lighting.

The generating plant (Fig. 3) occupies a small space in one end of the stable, the space being divided into two portions by a brick wall. One room contains the boiler and its necessary fixtures, and the other the engine, dynamo and switchboard. The battery occupies a small detached building (Fig. 2) about fifty feet distant, and in the immediate rear of the residence.

The boiler is a vertical one, rated at 15 HP, and is covered with cement. It occupies a floor space, including ash pit and piping, of 6 ft. × 6 ft. Fig. 1 shows the engine and dynamo. This direct connected unit, consisting of a Case engine and a Bernard dynamo, occupies a floor space of 2½ × 6¼ ft. The engine, operating at 80 lbs. pressure and 550 r. p. m., has its shaft direct connected to that of the dynamo by means of a flexible coupling, which always assures smooth running. The dynamo has a wrought iron field circuit, is shunt wound and has a capacity of 45 amperes at 125 volts. Fig. 3 shows the arrangement of the generating plant.

The battery consists of 42 cells of 500 ampere-hours capacity, and is of the "Chloride" type. The cells are arranged in series on shelves, permitting easy accessibility. 38 of the cells, with an average of 78 to 80 volts, are placed on the main circuit. The remaining four can be thrown in or out by the reserve cell switch, thus keeping the voltage constant. These extra cells are always kept fully charged. A plan of the battery room is shown in Fig. 2.

Fig. 4 shows the switchboard connections. The dynamo mains lead to a double-pole fused switch mounted on the switchboard, and wires lead from the switchboard to the storage battery room and to the house lighting circuits. The lamps in the house are installed on two separate circuits, and by means of switches, both of these circuits can be operated in parallel from either the storage battery or the dynamo, or one circuit may be operated independently from the dynamo and the other from the storage battery. The two house circuits are ordinarily connected to the battery in parallel; on special occasions, such as entertainments where considerable extra light is required, the dynamo supplies one circuit and the storage battery the other. The house is wired for 100 lights, but only from 25 to 35 are ordinarily used.

The dynamo voltage is regulated by means of a rheostat mounted on the switchboard. A wattmeter is connected in circuit to indicate the amount of charge and discharge. The reserve cell switch is mounted in the battery room. An automatic circuit breaker is used on the main line to prevent the battery current from flowing back to the dynamo, and is set to break the circuit at 5 amperes or less. The battery is charged twice a week with 45 amperes of current to commence with, which is gradually reduced to about 20 amperes at the end of the charge.

All details are so simple that a fifteen-year old boy employed about the place has entire charge of the plant, from firing the boiler to starting the engine and dynamo, charging the batteries and throwing the switches. In fact, the following instructions cover his entire duties:

"First. Fire boiler and get up 60 to 80 lbs. of steam. Second. Start engine and dynamo, and adjust the voltage of dynamo to about 120 volts. Third. Throw out the house switches (two) and throw in the battery switch. Fourth. Adjust the rheostat so that the ammeter indicates 45 amperes flowing through the battery; keep this up three hours, then reduce for three hours to 35 amperes, then further reduce for three or four hours more to 20 to 25 amperes. This will charge the batteries sufficiently for from three to eight days, according to the time of the year, etc."

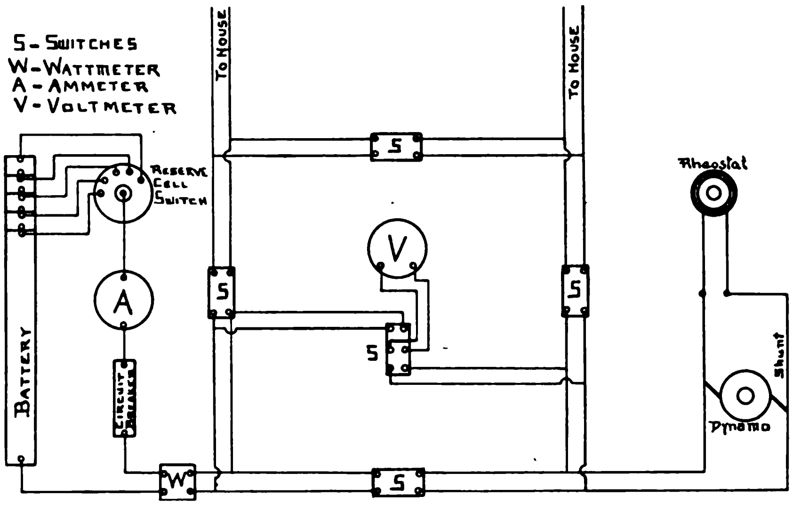


FIG. 4.—SWITCHBOARD CONNECTIONS.

A system for residence lighting even more simple than the above, is one employing a gas or gasoline engine belted direct to a dynamo. This system can be run at a remarkably low cost; in fact, there are small plants of this system running, in which the cost is stated to be not over one cent a day per 16-CP light. By using one of the latest type of gas or gasoline engines, great efficiency, simplicity and constant speed can be secured, and the lighting may be done direct from the dynamo without using a storage battery.

If, however, the first cost of a storage battery is not prohibitory, it will be found an extremely desirable addition, even with a gas engine; for while the gas engine will run without any engineer or special care, it is yet very convenient to fall back on the storage battery during the hours when only a limited amount of light is required. In addition, the storage battery will double the capacity of the plant for special occasions, as above noted.

Typical Electric Plant For Country Residences.

BY MAURICE BARNETT.

Up to a year or two ago the electric lighting of private residences was confined almost exclusively to those located in the cities. Very few country houses were thus lighted, as it was thought that in the absence of electric companies' mains an incandescent system could not be adopted except at a prohibitory cost. Further, it was imagined that if a generator plant were installed for country house lighting, the vibrations produced by the engine would be objectionable, and that it would be necessary to start the whole plant to take advantage of a single lamp.

It is the purpose of the writer to show, in the following paragraphs, that not only can electric lighting be carried on economically in the country, but that by means of a generator plant combined with a storage battery, the dynamo capacity can be doubled and light had at any hour of the day or night without the necessity of running the engine more than a few hours three or four times a week except where the full capacity of the dynamo is wanted nightly or to meet the demand for a special occasion.

With regard to the cost of operating an isolated plant in the country, it may be said that this is less than *equivalent* illumination can be had by any other known means save water power.

There is no question of this since the improvement of gas, gasoline and naphtha engines has made possible the use of a prime mover possessed of high efficiency, and in operating which there are no stand-over losses. It is a matter of common knowledge that a given amount of gas or oil used to operate an engine driving a dynamo will furnish more light than when this same gas or oil is burned from a tip or wick. The introduction of a storage battery in such a system renders it satisfactory in the highest degree, inasmuch as it makes possible an absolutely steady light produced at a cost lower than is possible with boiler and steam engine, and nearly as low as it can be by water power.

In order that this article may be of value to the practical electrician, the writer will take the case of a house in which thirty to forty lamps are used on an average, but which is wired for 100 lamps, all of which may be used on special occasions, and will consider the apparatus required and method of connecting up the same to meet the conditions that arise in such instances.

It has already been stated that for isolated plants the gas, gasoline and naphtha engines are efficient and economical; and as they can be started up at a moment's notice, require no skilled attention, demand little storage room for fuel, are very serviceable for this work. Next in importance is the dynamo, which should be, say, a 50-light shunt-wound machine supplied with a rheostat for regulating the E. M. F.

With regard to the battery, it can be stated that ordinarily 58 cells will give all the pressure required for house work. If the battery is placed too far from lamps or, in other words, if the resistance of circuit is greater than should be the case, it may be necessary to add a couple of extra cells. To ascertain the capacity the battery should have, it is necessary to know what work it has to perform. The case in point calls for a 50-lamp battery by which the output of the dynamos may be doubled on special occasions and which, being charged three or four times a week, would furnish all the light normally required day and night during the week. Figuring that 50 lamps require a current output of 30 amperes it is evident since the normal discharge rate is an 8-hour rate the capacity of battery should be 240 ampere-hours.

In addition to the foregoing, the following apparatus will be required: 2 ammeters; 1 voltmeter; 1 overload switch (for automatically cutting battery out of circuit if it should for any reason begin to discharge at too rapid a rate); 1 underload switch for automatically cutting battery out of charging circuit in case voltage of dynamo should fall below that of battery (in which case the battery would run the dynamo as a motor). There would also be required about 10 counter E. M. F. cells for reducing the battery pressure at beginning of discharge, and also for reducing the dynamo voltage on the lamps when the battery is being charged at the same time dynamo is used on lamps. Lastly, there would be required a 3-point voltmeter switch connected up with the voltmeter so that the voltage can be ascertained at any moment at the terminals of the dynamo, the terminals of the battery and on the lamps; also a counter-cell switch and a dynamo and a battery-switch.

The method of connecting in a storage battery plant where the generator is shunt-wound aud capable of giving the E. M. F. required (2 ½ volts per cell) for charging the battery, is shown in Fig. 1, in which

A = ammeters.
V = voltmeter
E = voltmeter switch.
G = bus bars.
L = lamps.
D = dynamo.
R = rheostat.
S = lamp switch.
S' = dynamo "
O = overload "
C = underload "
K = battery.
H = counter-cell switch.
P = counter E.M.F. cells

By reference to Fig. 1, it is seen that the lamps can be run from the battery alone or from the battery and dynamo working together in parallel. The drawing also shows that the voltage on lamps can be maintained constant, in spite of the high E. M. F. required to charge the battery, by the aid of the counter E. M. F. cells, which are arranged in circuit between the dynamo and the lamps and are always under control by means of the counter-cell switch.

For a lighting plant already in existence and in which the voltage of the dynamo is not great enough to charge the battery, the requisite E. M. F. may be secured by means of a supplementary dynamo or "booster," the field of which may be separately excited from the bus bars or from the terminals of the battery—the armature being connected in series with the main dynamo. By this arrangement the battery may be charged without increasing the voltage on the bus bars. It is furthermore of no consequence under this arrangement whether the dynamo is shunt-wound or compound.

Fig. 2 shows the method of connecting in a storage battery with a plant already in existence, in which the voltage of dynamo is not great enough to charge battery, and recourse is had to a "booster." The lettering is practically the same as in Fig. 1, only here *B* represents the booster; *D*, the leads to the dynamo, and *F*, the field circuit switch of the booster. The E. M. F. of discharge is regulated by switching out the counter E. M. F. cells as the voltage of the battery drops.

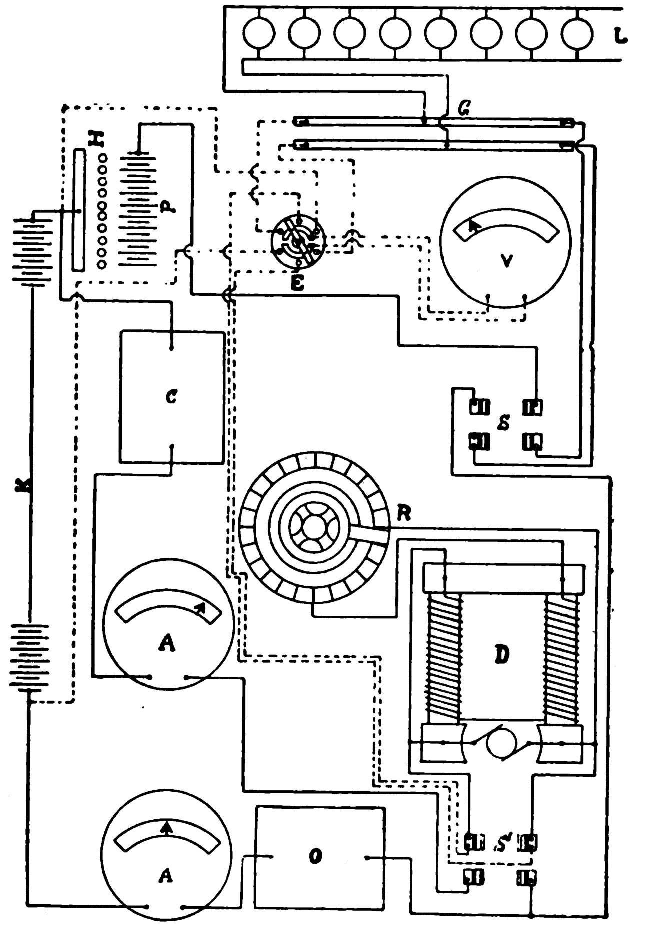


FIG. 1.—CONNECTIONS OF STORAGE BATTERY PLANT.

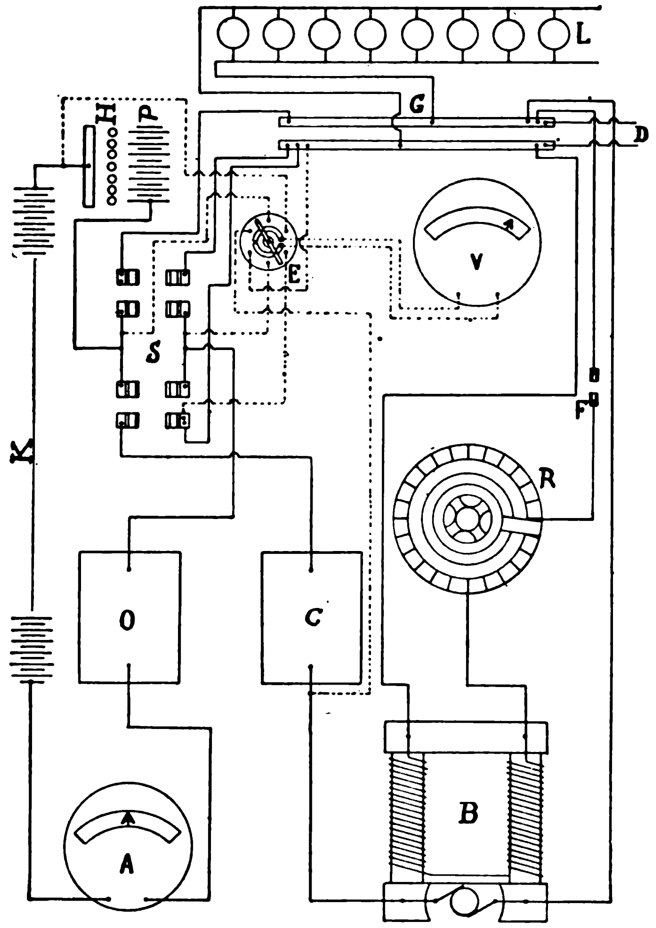


FIG. 2.—CONNECTIONS OF BOOSTER STORAGE BATTERY PLANT.

To the electrician who is not familiar with setting up batteries the following pointers may not come amiss.

See that the elements are clean. (Dirt may impair the purity of the electrolyte and lead to short-circuiting within the cell.)

Clean the lead lugs well before applying bolt connectors, which are to be screwed up tight in order to make a good connection.

Cells are always to be arranged in series. The negative pole may be distinguished from positive by reason of the fact that there is always one more negative than positive plate in every cell. The negative plates are gray; the positives, brown. Do not add electrolyte unless all the cells are joined up and current is available for charging. The electrolyte should be dilute sulphuric acid of Sp. Gr. 1.200. Mix electrolyte some time before using so that it will be cool when required. (Mixing water and sulphuric acid always produces heat).

Begin charging as soon as the cells are filled and continue for twenty hours at the normal charging rate prescribed by the manufacturer. If it be impracticable to charge continuously for twenty hours, charge, on successive days, at least ten hours each day uninterruptedly.

If the voltage of the dynamo is at least ten per cent. above the voltage of the battery, connect the positive lead from the dynamo with the positive terminal of the battery and close circuit. (As it is necessary to give the correct polarity to the generator proceed as follows: Cut out the armature by raising the brushes off of the commutator, then adjust the field rheostat so that all the resistance is in circuit and, finally, close the battery circuit; then the residual charge of the cells will send a current around the field magnets giving to them the correct polarity.) Charge until cells show 2.5 volts per cell. Do not discharge down below 1.8 volts per cell, and *never allow cells to stand when discharged.* When run down charge immediately.

If it be not intended to use the cells for a long time, say two months, treat as follows: Charge up fully, draw out 25 per cent. of capacity, remove the elements from the electrolyte and rinse well with water. When the elements are again to be put in service, add electrolyte and charge 20 hours—the same as with new element.

New cells do not give their full capacity until 10 or 15 discharges have been made.

The plates must always be covered by the electrolyte.

The density falls during discharge and rises during charging.

Test the cells separately from time to time with hydrometer and cell tester. If any show low voltage, which cannot be overcome by careful watching, cut out during discharge and reinsert on charging.

By attending to the foregoing instructions no trouble will be had with a battery plant.

In the first part of this article attention was directed to the practicability of using gas, gasoline and naphtha engines for isolated plant work on the ground that with this form of motive power, electricity could be generated cheaply. Thus far nothing has been said regarding the relative first cost of a steam engine plant and a gas engine-storage battery plant. Within the limits of an article like the present one, an analysis of this expense cannot be attempted. It is evident that the steam engine plant is free from the cost of a storage-battery; but on the other hand the gas engine battery plant is free from the expense of steam generating apparatus. Whatever the difference between the two it will not be very great. Even if the gas engine battery arrangement were slightly expensive, the increased cost would be justified a dozen times over by reason of the better light afforded, the facility with which some light can be had at any hour of day or night without the necessity of starting up generator, and the fact that no skilled help is needed to run a gas engine plant.

From considerations like these it must be evident that the electric lighting of country houses is practicable whether looked at from the point of view of first cost, operating expenses, ease of manipulation or adaptability of plant to the needs of the owners. This last point is quite a desideratum. Most persons like to have their house quiet at night. With a gas engine-battery plant there would rarely be any necessity for running generator at night.

These facts have but lately received general recognition, and already there has been a rapid extension of country house lighting, a fact which indicates that in the next few years, when the practicability and utility of a combination of generator plant with storage battery for country houses is better understood, there will be even greater activity in this kind of installation.

THE BERLINER PATENT SUIT.

The celebrated suit of the United States against the American Bell Telephone Company and Emile Berliner, for the cancellation of the Berliner Patent No. 463,569, dated Nov. 17, 1891, came before the United States Supreme Court, Nov. 9, for final disposition.

This suit was begun in Feb., 1893, by the Attorney General on behalf of the United States for the purpose of cancelling the Berliner patent filed June 4, 1877, and issued, after a delay of more than fourteen years, on Nov. 17, 1891, to the American Bell Telephone Company, assignee of Emile Berliner. The case was originally brought before the Circuit Court, District of Massachusetts, and on Jan. 3, 1895, Judge Carpenter decided in favor of the Government and ordered the patent cancelled. His decision embraced two of the grounds set up by the United States urging the cancellation of the patent.

On appeal by the American Bell Telephone Company, the Circuit Court of Appeals of the same judicial district adjudged in favor of the American Bell Telephone Company, overruling Judge Carpenter's decision on the ground of lack of jurisdiction. The United States then appealed the case to the Supreme Court.

The case was opened on Monday, Nov. 9, by Judge R. S. Taylor, of Ft. Wayne, for the Government, who was followed by Joseph H. Choate, of New York, and F. P. Fish, of Boston, for the American Bell Telephone Company. Causten Browne, of Boston, and Chas. H. Aldrich, Ex-Solicitor General of the United States, also appeared for the Government, the latter by special appointment by the Attorney General as Special Assistant Counsel for the United States to file a supplemental brief discussing in greater detail some of the grounds upon which the United States urges the cancellation of the patent.

The bearing of this famous Berliner patent upon the telephone situation is briefly as follows:

On Mar. 8, 1876, Alexander Graham Bell was granted a patent, No. 174,465, covering fundamentally and broadly the method of, and apparatus for, transmitting and receiving speech electromagnetically. Bell also claimed "The *method* of producing undulations in a continuous voltaic circuit by gradually increasing and decreasing the resistance of the circuit * * * as set forth." Thus Bell patented the *method* of the microphone. He did not, however, patent the *apparatus*.

This may have been due to the fact that he considered, at that time, that the magneto transmitter was more important than the battery transmitter or microphone. Under this fundamental patent however, the American Bell Telephone Company, justly maintained their monopoly of the telephone business up to the year 1893.

On Apr. 14, 1877, Emile Berliner filed in the patent office a caveat and on June 4, the same year, an application for an invention which, after various amendments (the entire specifications and drawings having been twice stricken out and erased and new ones substituted), was finally, on Nov. 17, 1891, issued to the American Bell Telephone Company, and is now construed by them to cover all forms of battery transmitters or microphones. In other words, it is the *apparatus* patent on the microphone which Bell failed to claim, or, more exactly, the first claim is a "process" claim, claiming the "mode of operation" of the microphone. Claim 1 reads: "The method of producing in a circuit electrical undulations similar in form to sound waves by causing the sound waves to vary the pressure between electrodes in constant contact, so as to strengthen and weaken the contact and thereby increase and diminish the resistance of the circuit, substantially as described."

The second claim is strictly for the transmitter as an apparatus operating by the method, or mode of operation, described in the first claim.

During thirteen years out of the fourteen years this patent was lying as an application in the patent office, the Bell Telephone Company, under the protection of Bell's broad method patent, was reaping the profits of the exclusive use of the identical apparatus which this patent as issued is claimed to cover. The Bell Telephone Company now claims the right to continue the exclusive use of this apparatus until the year 1908, under the protection of this delayed patent; a total period of protection of more than twenty-two years.

Judge Taylor and Mr. Browne argued before the Supreme Court the two points on which Judge Carpenter adjudged in favor of the United States, namely:

First, the uncalled-for delays in the Patent Office which made the issue of the patent unlawful and amounted to bad faith on the part of the American Bell Telephone Company toward the public.

Second, the bearing of the 1880 patent to Berliner, in which is disclosed and described and patented the identical apparatus of the patent in suit, claimed both as a receiver and as a transmitter in combination with the same apparatus as a receiver.

The American Bell Telephone Company argues, in reference to the delay in the office, that whatever delay there might have been was not unprecedented, and was due to the rules of the Patent Office, over which it had no control, and concerning which it should not be held responsible.

In reference to the second point, the American Bell Telephone Company claims that the 1880 Berliner patent was for a *receiver* and was an entirely distinct invention from the transmitter patent of 1891, the patent in suit, and, moreover, this receiver had never gone into public use.

Concerning the delay in the office, it may be stated that whoever may have been responsible for the delay, it was the American Bell Telephone Company which profited thereby. Also, that during a large portion of the fourteen years the delay was caused by interference suits, both sides of which were owned by the Bell Company.

In reference to the 1880 patent, it is certain that the fourth claim claims the combination of a transmitter and receiver of identical construction with the transmitter in the patent in suit. But the patent in suit claims the transmitter *per se*. Therefore, as Judge Aldrich argues, "the system of the claim of the 1880 patent could not be practiced without infringing the claims of the 1891 patent. This fact alone establishes the identity of the two patents and the illegality of the second patent" (the patent in suit). This is the ruling of the United States in the recent Miller *vs.* Eagle Manufacturing Company.

Some of the other points argued in detail by Judge Aldrich are as follows:

First. "The application as filed June 4, 1877, did not describe the constant contact transmitter which is covered by the patent." Berliner states in his application of June 4, 1877, when describing his transmitter, consisting of a single pin electrode, and which could be made to operate by constant contact, *i. e.*, without breaking the circuit:

"These simple instruments will reproduce any musical sound uttered in the neighborhood of one of them, but for special sounds, *such as speech*, they are *not adapted*, and for the following reasons." Berliner then proceeds to discuss these reasons, and then, speaking of the reproduction of speech, says, "this I accomplish, however, by situating within the vibrating field of the plate, *A*, a second screw, *E*." This second screw is situated on the opposite side of the diaphragm from the first, and the operation of the instrument is necessarily by "makes and breaks," instead of "constant contact." It was only by twice striking out the entire specifications and drawings, and substituting new ones, that the constant contact feature was brought into the application. These amendments were not sworn to by Berliner until the constant contact transmitters had been in commercial use for more than three years, that is, over a year longer than Berliner could claim a legal right for a constant contact transmitter patent.

Second. "The Berliner patent is void because of irregularities of procedure in the Patent Office aside from questions of delay and insertion of new matter." Judge Aldrich shows that the primary examiners in the Patent Office who had Berliner's application in charge, all officially declared that the invention in question was not contained in the application as filed June 4, 1877. The counsel for Berliner appealed to the Commissioner in person, who, without it having first passed through the Board of Examiners-in-Chief, as required by law, decided the invention was contained in the original application, and under this ruling the patent was finally passed to issue. The American Bell Telephone Company claims that the result would have been the same any way, as the Commissioner had final jurisdiction; but one object of the Board of Examiners-in-Chief was to enlighten the Commissioner and prevent mistakes, and they were required by law to "be persons of competent legal knowledge and scientific ability" (requirements not specified for the Commissioner).

Third. "The Berliner patent is void because the process and apparatus therein claimed were described by A. G. Bell in his patent No. 174,465, of Mar. 7, 1876, and were a part of Bell's invention disclosed in that patent."

Bell first successfully transmitted speech in May, 1876, and transmitted it by the variable resistance method and apparatus, *i. e.*, his liquid transmitter. It appears from the testimony of the American Bell Telephone Company in previous cases that this liquid transmitter of Bell's was an operative constant-contact transmitter or microphone, and, contrary to popular opinion, electrically different from the Grey liquid transmitter in which the electrode was immersed deeply in the liquid, instead of just touching the surface, as in Bell's. Furthermore, the electrical action of Bell's, is identical with the electrical action of Berliner's transmitter; the variation in resistance of each being accomplished solely by means of a variation in the area of contact at the point of contact, and the variation in resistance being necessarily accompanied by a variation in pressure between the electrodes in both instruments. It thus appears that the method and apparatus of the Berliner patent is identical with the method and apparatus employed by Bell. Though Bell failed to patent the *apparatus* of his method, yet no subsequent inventor could legally patent this apparatus or mode of operation. Therefore, the most that Berliner was entitled to was the structure actually claimed by him. The structure has never gone into public use and is unfitted for the commercial transmission of speech.

Mr. Aldrich also calls attention to the Edison carbon patents, the companions of the Berliner patent in their long sleep in the patent office, which were designed to prolong the monopoly of the American Bell Telephone Company by means of the fundamental claims on the use of carbon for telephone transmitters, and which were actually issued by the Patent Office subsequent to their expiration under British limitation.

It will be remembered that the American Bell Telephone Company strove to prolong the life of these patents by joining in the attempt to change the interpretation of Section 4487 of the Revised Statutes, referring to foreign limitation, but was defeated by the decision of the Supreme Court in the Bate Refrigerating case.

It thus appears that the Berliner patent is the only obstacle which now prevents the public from enjoying the advantages of active competition in an industry already protected by the patent office for more than twenty years. The decision remains with the Supreme Court.

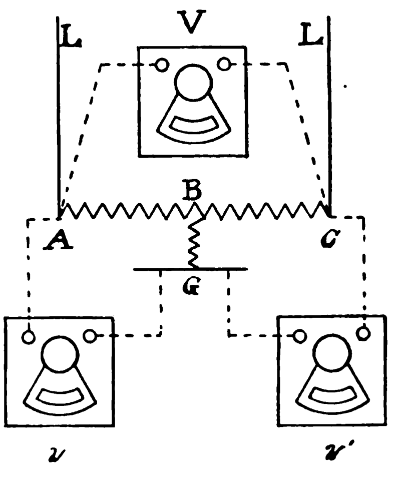
THE USE OF A VOLTMETER FOR MEASUREMENT OF INSULATION RESISTANCE.

BY WM. R. C. CORSON.

It is frequently desirable to determine the resistance of the insulation between the ground and a system of wiring, a dynamo, or other translating device, while the system is in operation, and for this purpose the method described below will be found convenient. The formula is by no means new, but as the writer can find no article in which its derivation is published, and as he has met so many electrical workers who were not familiar with it, to whom the method would be of advantage, it has appeared probable that its publication would be of some interest.

In the diagram, $L\,L$ represent the mains of the constant potential circuit, $A\,B\,C$ is the system or translating device grounded at some point or points, B. It is desired to find the resistance of the insulation, $B\,G$.

One voltmeter is used, the resistance of which is known, and readings are taken across the mains, denoted by V, between ground and positive main, denoted by v, and between ground and negative main, denoted by v'



V' is the sum of readings v and v' R is the resistance of the voltmeter, and s is the resistance of the ground insulation, which it is desired to determine; Now, drop of potential in $A\,B$ + drop in $s + v' = V$;

or drop in $A\,B + \frac{v'}{R} s + v' = V.$ (1)

and drop in $B\,C + \frac{v}{R} s + v = V$ (2.)

adding (1) and (2.)

drop in $A\,B$ + drop in $B\,C + v + v' + s\,\frac{(v + v')}{R} = 2V$ (3).

But drop in $A\,B$ + drop in $B\,C = V$, (4.)

and $v + v' = V'$ (5.)

Substituting these values in (3.),

$V' + \frac{s\,V'}{R} = V.$ (6.); $s = R\,\frac{V - V'}{V'}$ (7.).

It will be noted that there is a slight error in these equations, and that they will only be correct on the assumption that the combined resistance of voltmeter and ground is so great that the current flowing through the path will not affect the drop in potential through such conductors as $A\,B$ and $B\,C$. This assumption is always necessary in measuring drop of potential with a voltmeter.

Let us take an example or two.

We have a Weston portable voltmeter resistance is 60,000 ohms. We find the whose ground reading between the positive line of a 500 volt circuit and ground to be 35 volts, and on the negative side 15 volts. Substituting these in formula (7.) We have $s = 60{,}000\left(\frac{500 - (35 + 15)}{50}\right)$, or $s = 540{,}000$ ohms.

Suppose again that the line was metallicly grounded on the negative side, and let us make readings, and apply formula. V would be 500, the voltage of the line; v would also be 500, because it would be the reading from positive main to ground which, being metallicly connected with the negative main, has taken its potential. For the same reason v' would be 0. Formula would become $s = 60{,}000\left(\frac{500 - (500 + 0)}{500}\right)$ or $s = 0$, which, of course, was to be expected.

◆

Modern Science.—Dr. John Trowbridge in a recently published book entitled "What is Electricity," gives as the characteristic of physical science to-day, its reliance upon patient observation and the study of the transformation of electricity into light and heat, or the transformation of heat into electricity. A well trained physicist listens, he says, with as much intolerance to the speculations of a philosopher on the origin of force, as Moltke would have listened to the philosophical faculty of the University of Berlin on the origin of war. The great modern intellectual movement in physical science, Dr. Trowbridge considers, resides in the abandonment of mere speculation, and the subsitution for it of the study of detail and the investigation of the economy of Nature in the transformations of the store of energy which has been vouchsafed to the world. Every university in the world now has systematic laboratories; and the methods of patient investigation which characterize the laboratory study of science are slowly creeping into the study of other subjects, notably that of law, and are destined, Dr. Trowbridge believes, to be adopted in all subjects. Lord Salisbury in his 1894 B. A. address said, "the science in the universities for many generations represented the knowledge which alone in the Middle Ages was thought worthy of the name of science. It was the knowledge gained not by external observation, but by mere reflection. The student's microscope was turned inward upon the recesses of his own brain, and when the supply of facts and realities failed, as it very speedily did, the scientific imagination was not wanting to furnish to successive generations an interminable series of conflicting speculations." Dr. Trowbridge adds that the physicist of to-day has his ethers and his atoms just as the ancient Greek and Roman philosophers had theirs, and he pictures to himself invisible motions far more subtle than entered the imagination of Aristotle or Democritus. The natural philosopher of to-day, Dr. Trowbridge asserts, differs in this essential respect from the ancient philosopher—he measures. If his heat measures do not agree with his hypotheses of vortical or atomic motions, he rejects his attractive hypotheses instead of hugging them.

GAS AND OIL ENGINES FOR ELECTRICAL GENERATION.

The first practical gas engine—that of Lenoir—was made in 1860, while the forerunner of the present types of gas and gasoline engine exclusively manufactured only dates from 1876, when the Otto principle was first applied. In Europe this type of thermal generator has met with much wider acceptance than in this country. Up to 1886, or in ten years, no less than 15,000 Otto cycle engines were sold, and at the present time a single one of the many British manufacturers of gas engines turns out 60 per week.

While the United States has heretofore been rather backward in the use of this form of prime motor, during the past year there has been evidence of an awakening of interest, both on the part of manufacturers and of the public directly interested. The lack of interest previously manifested is difficult to understand, for the merits of the gas engine rest upon such solid foundations, as demonstrated by European practice, that neglect in recognizing them in this country is somewhat singular.

Much has been said, but upon insufficient premises, concerning the lack of regulation in gas engines, and consequently their inapplicability to electric lighting. In the first days of the incandescent lamp much was also said in the same connection concerning the steam engine, but in a very short time types were upon the market that left nothing to be desired on that score. At the present time guarantees can be obtained from the manufacturers of gas engines intended for electric lighting service, which are perfectly satisfactory as to regulation.

In the case, however, of the purchaser of a steam engine, for incandescent lighting, he seldom failed to exercise the necessary discrimination, nor objected to pay the higher price for an engine specially fitted for that service. He was guided in this by the practice of calling such engines "automatic" or "electric light" engines, and was thus less likely to invest in engines not recognized as coming within such a classification. The lack of such a guide in the purchase of a gas engine has undoubtedly resulted in much dissatisfaction. In instances where gas engines have failed to give satisfactory results in electric lighting, it will generally be found that a cheap type has been used from which good results could no more be expected than from a saw-mill steam engine employed for the same purpose.

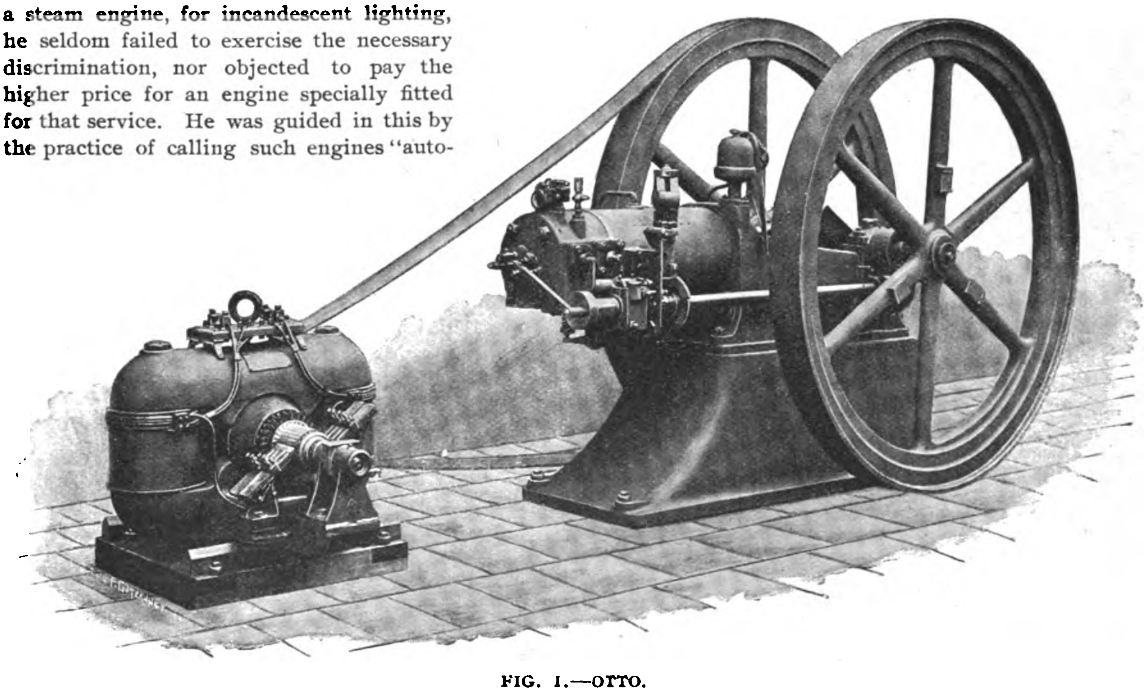


FIG. 1.—OTTO.

The future of the gas engine is by no means confined to use in isolated lighting, or to small powers. They have been made in sizes as large as 500 HP, and a number of central stations in Europe are operated by gas engines. One of the latest of these is at Belfast, Ireland, this type of prime mover having been recommended for use there by Prof. Kennedy, the eminent mechanical engineering authority, who acted as consulting engineer. Six engines are used and on test in ordinary service they showed a consumption of gas at the rate of 24 cu. ft. per HP hour. More recently the gas engine has been adopted as a prime mover at the Danbury (Conn.) central station, where it is giving much satisfaction.

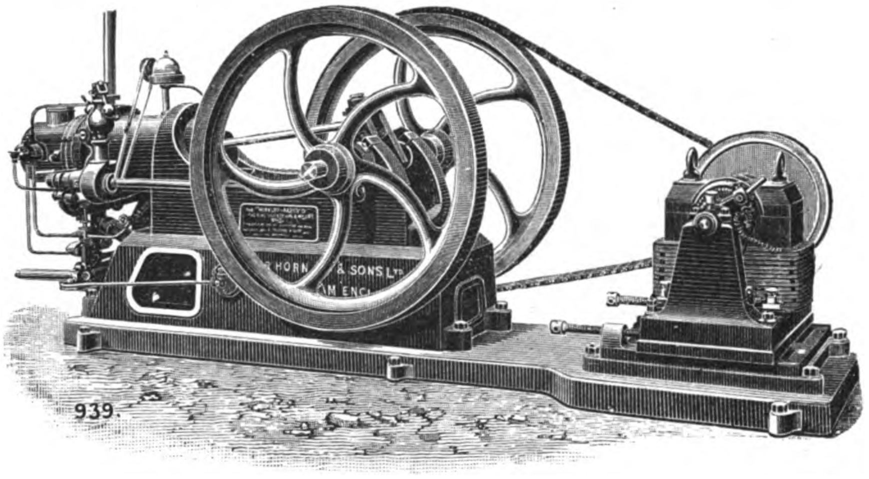


FIG. 2.—HORNSBY-AKROYD.

It is well known that a given illumination may be obtained from electric lamps fed from a dynamo driven by a gas engine, more cheaply than if the gas were burned direct from jets. The comparison is simple to arrive at, which is done as follows:

Assume that a 16 CP jet may be maintained with 5 cu. ft. of gas per hour, and that the price of the gas is $1.00 per thousand cubic feet. Then each thousand cubic feet will give 200, 16-CP hour jets, or at the rate of ½ cent per jet per hour.

At the rate of 33⅓ cu. ft. of gas per electrical HP-hour (which is a liberal allowance), the same quantity of gas will generate 30 HP-hours, or 30 × 745 = 22350 watt-hours. With 50-watt 16-CP lamps this will give 447 lamp-hours. The cost per lamp-hour is thus $\frac{100}{447}$ cent, or less than ¼ cent per lamp-hour—that is, less than half as much as the cost of burning gas direct from jets. As some manufacturers will guarantee a horse power on less than 20 cu. ft. of gas per hour, this comparison is an outside one.

As an instance of the saving that may be attained from the use of the gas engine, the following figures have been published with reference to the Southampton (England) Public Library:

The cost of electric lighting for a certain period, if current had been taken from the street, would have been $240; the cost of gas at 62 cents per thousand would have been $120; the actual cost of lighting from the gas engine plant installed was $90 for the same period.

Makers have guaranteed large gas engines to develop an hourly horse power on 1 lb. of coal, using Dowson gas, and a usual guarantee for smaller sizes is the equivalent in gas of 1½ lbs. of coal. Trials of large engines have given a consumption of 17 cu. ft. of gas per I. HP, and engines of even very small size have on test developed a horse power with 25 cu. ft. of gas per hour.

With few or no exceptions, all gas and oil engines now made work according to either the Otto or Clerk cycle, and are usually single acting. Since the expiration, about 1890, of the fundamental Otto patent, the four-stroke or Otto cycle appears to have entirely driven the other out of the field.

With the Otto cycle and a single cylinder, there is one impulse to two revolutions of the engine shaft, or to four strokes of the engine, the operation being as follows:

1. A charge of gas and air (about ten parts of air to one of gas) is drawn in the cylinder on the in-stroke. 2. Upon the return stroke this charge is compressed, and is exploded when the piston arrives at the end of its out-stroke. 3. The pressure from the exploded gases drives the piston on its in-stroke. 4. The burnt charge or products of combustion are driven out on the return stroke. The next stroke is (1).

With the Clerk cycle there is one impulse to each revolution, and the charge of air and gas is compressed in a second cylinder, or in the other end of the motor cylinder, the operation being as follows:

1. A charge of gas and air forced under slight pressure into the motor cylinder, drives out the products of combustion when the piston reaches the end of its in-stroke, and this charge is compressed on the out-stroke. 2. The charge is exploded when the piston arrives at the end of its out-stroke. The second cylinder during the out-stroke draws in the gas and air charge, compresses it slightly on the in-stroke and then discharges it into the motor cylinder as described in (1).

Oil engines do not differ from gas engines in their methods of operation, but, of course, have in addition a mechanism for vaporizing or spraying the oil.

Below are illustrated and described the principal gas and oil engines now used in the United States, including several but recently placed on the market.

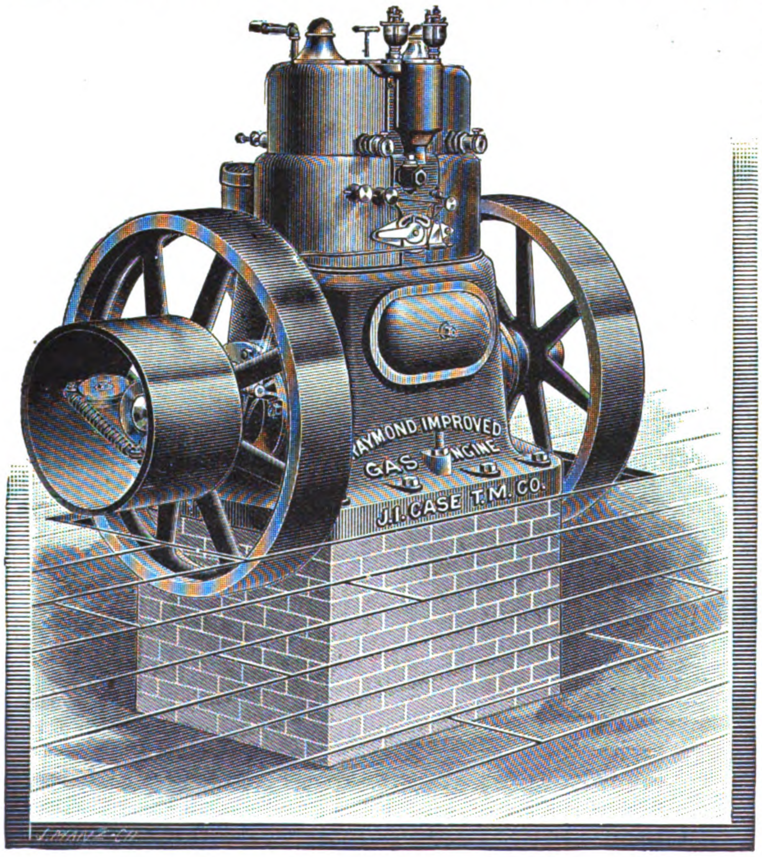


FIG. 3.—BIRKHOLZ.

In Fig. 1 is illustrated one of the latest types of the Otto gas and gasoline engines. The engine shown is of 9 actual HP directly belted to a dynamo. The makers of this engine claim to be the first to build an engine in which the regulation of the speed is so close as to admit of direct driving of a dynamo and the obtaining of perfectly steady lights, which previously could only be produced by the use of a cumbersome heavy balance wheel and countershaft. They state that they have hundreds of electric light plants in successful operation with installations ranging from two to 300 HP. The latter is the largest single installation for electric lights in the United States, and consists of three 100-HP engines running in the plant of the Danbury & Bethel Electric Company.

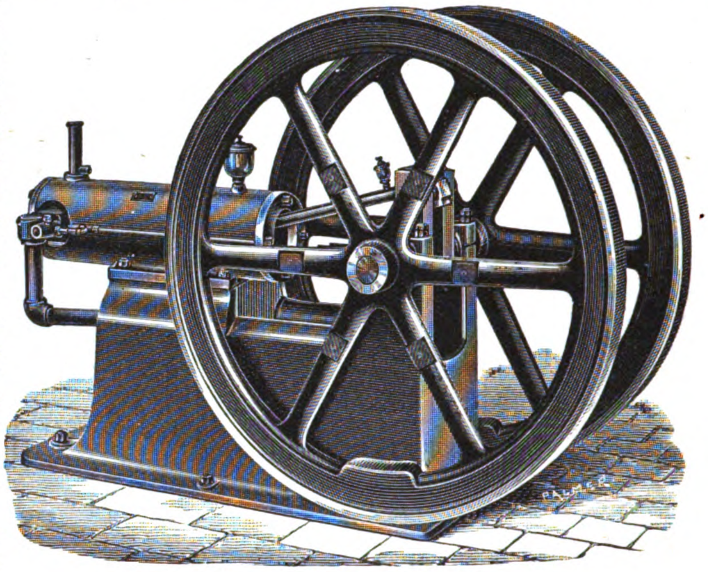


FIG. 4.—WHITE & MIDDLETON.

The special features of this type of engine consist in having all valves, which are of the direct acting poppet valve type, placed in separate casings, which permits of their being easily removed for cleaning; and the use of a timed electric igniter, and separate water jackets around the cylinder. All bearings are bronze-lined with automatic ring oilers. Spiral valve gearing is used, thus dispensing with noisy running. The governor is of the well-known change-speed type. The engines are built in sizes from two to one hundred HP.

The Hornsby-Akroyd oil engine, shown in Fig. 2, has one peculiarity which distinguishes it from the other heat motors of its class, which is that it has neither a hot tube, an electric spark, nor a slide valve with flame to explode the charge of oil and air, and is therefore, perhaps, the simplest oil enginer now on the market. A peculiar feature is that no attempt is made to vaporize the oil, or convert it into spray until it is actually injected into the combustion chamber. Hence the density of the oil is a point of no importance, and heavier petroleum may be used than in most other engines. The specific gravity of the oil is usually about 0.850, and its flashing point 150 degs. F., but the engine will work with oil of specific gravity 0.854, and a flashing point of 220 degs. F., thus securing perfect safety in operation.

The chief objection to gas and oil engines in general is the necessity of igniting the charge artificially, which objection is obviated in the Hornsby-Akroyd type. The manner in which the explosion is obtained in this engine is as follows:

The cylinder is provided with an extension communicating with it by a relatively narrow neck. This extension is unjacketed and forms a retort in which the oil is vaporized. Nothing but oil in liquid form is injected into the retort and only air is drawn into the cylinder. On the inner stroke of the piston air is drawn into the cylinder and oil is injected into the hot

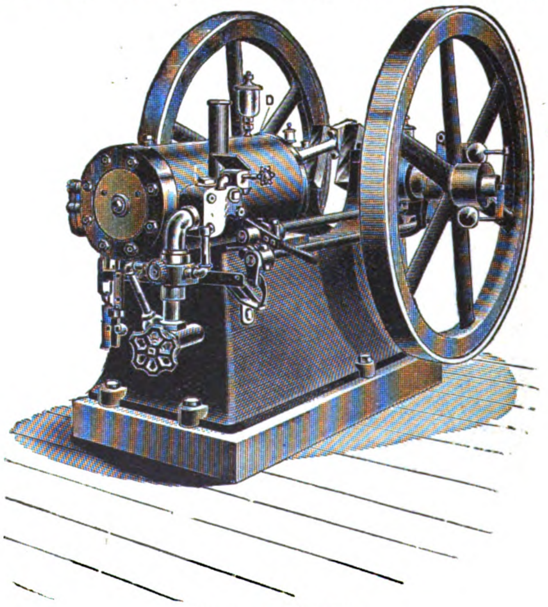


FIG. 5.—WEBSTER.

retort. At the end of the stroke there is in the retort oil vapor, which is not in itself explosive, and in the cylinder pure air which is also non-explosive, nor is there sufficient leakage from one to the other to make either charge explosive. On the return stroke of the piston, the air is forced from the cylinder through the communicating neck into the retort. For a moment the mixture of oil vapor and air is too rich for explosion, but as the piston progresses sufficient air is forced in to make the mixture naturally explosive. This automatic explosion is found to take place exactly as the piston is making the return stroke. Ignition takes place within the retort, the piston being protected by a layer of pure air.

Analyses made of the gases indicate that the oil is completely burned in the cylinder with an excess of oxygen. The products of combustion formed consist mainly of steam and carbon dioxide diluted with nitrogen and oxygen, traces of carbon monoxide being detected, so that the exhaust is not objectionable. The oil is sent to the retort by a small pump, which always supplies enough for the full power the engine is expected to develop. If less power is being used, the speed increases a trifle, and a high-speed Porter governor opens a by-pass and allows the surplus oil to return to a reservoir cast in the base plate.

In Fig. 3 is shown the Birkholz engine, recently placed on the market, whose most important feature is the method of governing employed, by means of which the number of explosions is always the same, but the strength of the impulse is varied by the strength of the gas and air mixture. The makers state that a single cylinder, 2-HP engine equipped with this governor will hold the finger of a Weston testing voltmeter so still that it is almost impossible to observe a quiver. This particular engine is belted with an "Acme" link belt direct to a 2-KW Bernard dynamo.

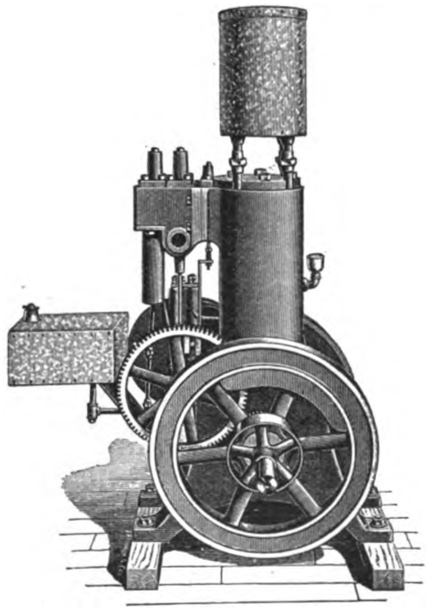


FIG. 6.—PROUTY.

The engine is of the four-cycle type, which, the makers claim, is the simplest and best, as the piston does all the work—needing no other devices, which only complicate the machine. It is built in single, double and quadruple cylinders, the multiple cylinders being employed for economy of space and gas, neatness of design, and to lighten the force of the explosions. The makers state that they do not depend upon multiplying cylinders for steady power as a single-cylinder engine will govern almost as closely as a quadruple one. They consider that the vertical gas engine contains many features of superiority over the horizontal type; the rocking motion is almost entirely absent and where engines are placed in certain localities such as the tops of building, this is a great advantage; the vertical type gives the engine a more mechanical appearance, and economizes space, the 50 HP engine not exceeding 5 ft. × 7 ft. of floor space.

Where gas is used for fuel the hot tube is employed for igniting the charge, the tube being guaranteed not to burn out within a year. Electrical igniters are not reliable. All size engines are self starting.

The principal feature of the White & Middleton gas and gasoline engine, shown in Fig. 4, is the method of exhausting through an open port in the cylinder, which port is uncovered by the piston near the end of its in-stroke. The operation of the engine, which works on the four-stroke cycle, is as follows:

The gas and air is drawn into the cylinder by the in-stroke of the piston, is compressed by the following out-stroke and ignited by an incandescent closed tube, the charge being exploded and the impulse received on the in-stroke. The exhaust port in the side of the cylinder is uncovered by the piston at its extreme in-stroke, and nine-tenths of the products of combustion are discharged. This first discharge includes all the fire and heat. The balance, one-tenth, of the burnt charge remaining in the cylinder at atmospheric pressure is expelled through valves at the end of the cylinder by the following out-stroke, which completes one working cycle. This second, or supplemental, discharge contains no fire or heat to affect the valve, but merely discharges the small portion of foul gases left in the cylinder. The valves are all of the poppet type, and a ball governor controls the admission of the gases.

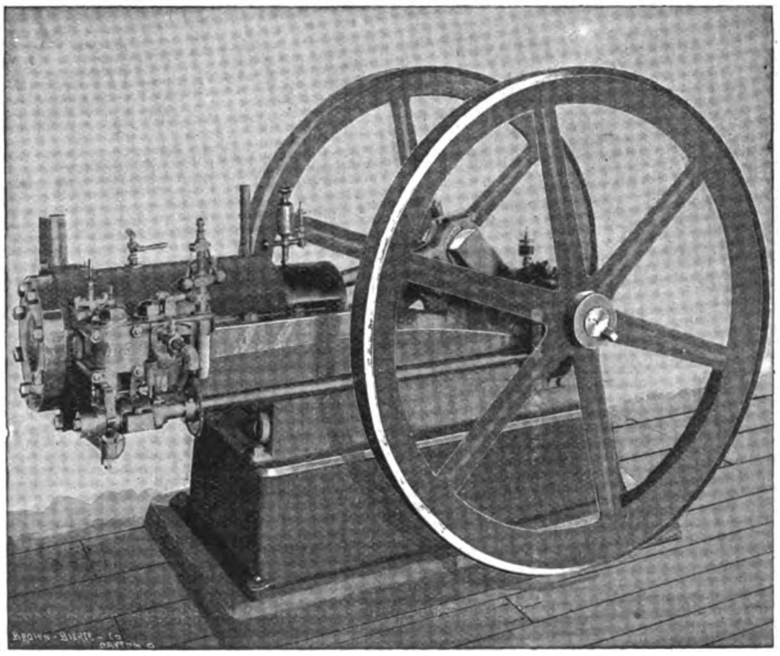


FIG. 7.—"NEW ERA."

When the engine runs at its full capacity the valves open at every other revolution; when less work is required they do not open as often. The incandescent closed tube igniter, which fires the charge, works with positive and prompt ignition without the loss of a single charge even with a speed of 400 r. p. m. The tube is a one-quarter inch pipe, closed at the top and screwed into the cylinder, and is kept red hot by a Bunsen burner.

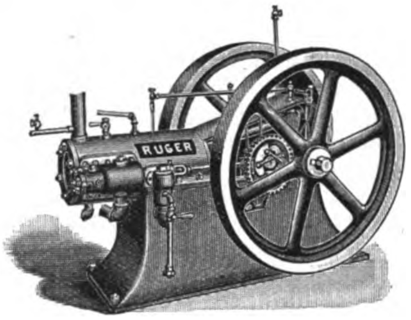


FIG. 8.—RUGER.

The charge of mixture under compression rushes up into this incandescent pipe and is ignited.

The Webster gas and gasoline engine is illustrated in Fig. 5. The makers claim high economy and close regulation for this type. All engines are tested to assure these points before sending out, by being run connected with a dynamo, the current from which lights a bank of incandescent lamps. The engine uses the hot tube or the electric method of ignition, or both are fitted, as desired.

Where gasoline is used, gravity flow is not used, a pump delivering into the vaporizing chamber the small amount of liquid required for each explosion. There is never remaining in the vaporizing chamber over three or four tablespoonfuls of gasoline, the remainder passing at once back to the supply tank through the overflow pipe.

The Prouty gasoline engine is shown in Fig. 6. In the small sizes of this type the cooling water is contained in a tank over the piston, as in the engraving, and circulates by gravity. The gasoline tank is usually attached to the engine at the side. The amount of water required is stated by the manufacturers to be very small, a few pailfuls being sufficient for the 5-HP size.

The "New Era" gas engine, shown in Fig. 7, is of the four-stroke cycle type, and manufactured in sizes from 10 to 60 HP. Among the features claimed for the machine are slow speed and very heavy parts, which assure longer life and high economy.

Coal gas, natural gas or gasoline can be used for fuel, and when so ordered the engine is built to change from one to the other without stopping. The water-jacket (which in all gas engines should be cleaned once a year) can be reached by simply removing the cylinder head. The valves and igniter are all operated by cams on a single lateral shaft driven from the crank shaft by spiral gears. The governor is of the ordinary ball type, driven by bevel gears on the lateral shaft, and can be adjusted for the engine to run at any desired speed within its limits. When the speed is above normal, the governor cuts out the fuel and continues to do so until reduced to normal, when fuel is again taken. At times when the fuel is cut out, fresh air is drawn in and exhausted by the action of the piston, which not only insures the complete cleaning out of all burnt gas, but tends to cool the valves and cylinder.

The valves are all of the vertical poppet style, and are self-cleaning, and any one of the working parts can be removed very quickly without disturbing any other part. When gasoline is used, the supply tank is usually buried in the ground, outside the building, and a pump on the engine pumps the fluid to the engine, where its admission to the cylinder is controlled by the injector valve. What fluid is not needed returns to the supply tank by an overflow pipe. No explosive mixture is contained about the engine, consequently the use of gasoline is as safe as gas, as none of the fluid is exposed to the air. The makers state that the "New Era" engine will start as readily in winter as in summer, and that its construction is such that any man of ordinary ability can soon learn to handle it with perfect ease.

A 10-HP Ruger gas and gasoline engine is illustrated in Fig. 8. The same type is made in vertical forms for powers of 8 HP and less. The Ruger gas engines have three simple poppet valves and two valve chambers, which are reduced to two and one, respectively, when fitted for gasoline. The valves can be easily removed and put back in place in a minute's time, and no fine adjustment is required with them or elsewhere about the machine. Hot-tube or electric igniters are fitted, the former being recommended by the makers.

The governing is accomplished by automatically controlling the exhaust valve—that is, holding it open when the speed is up to the normal. This method is claimed to be economical, as well as efficient, since it relieves the piston from doing work in compressing idle charges of air when the engine is running light. The governor is sensitive in action, the work thrown on it being very light, as its function is merely to indicate the time that the engine is to take an impulse. When required, a device is attached for changing the speed of engine while in motion, which is sometimes found advantageous.

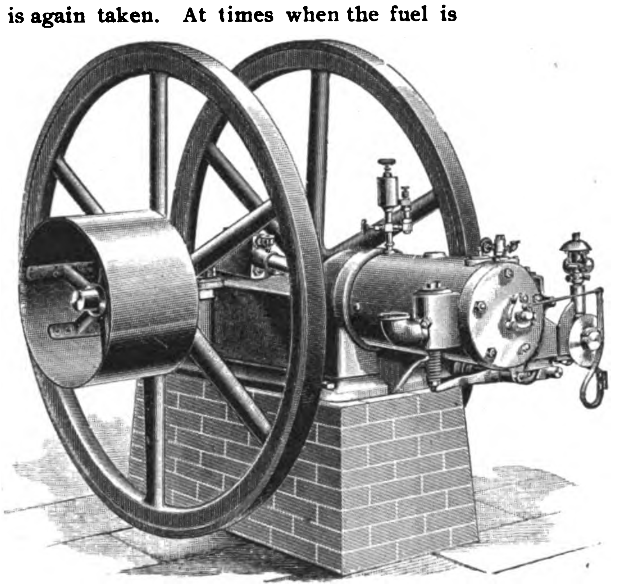


FIG. 9.—LAMBERT.

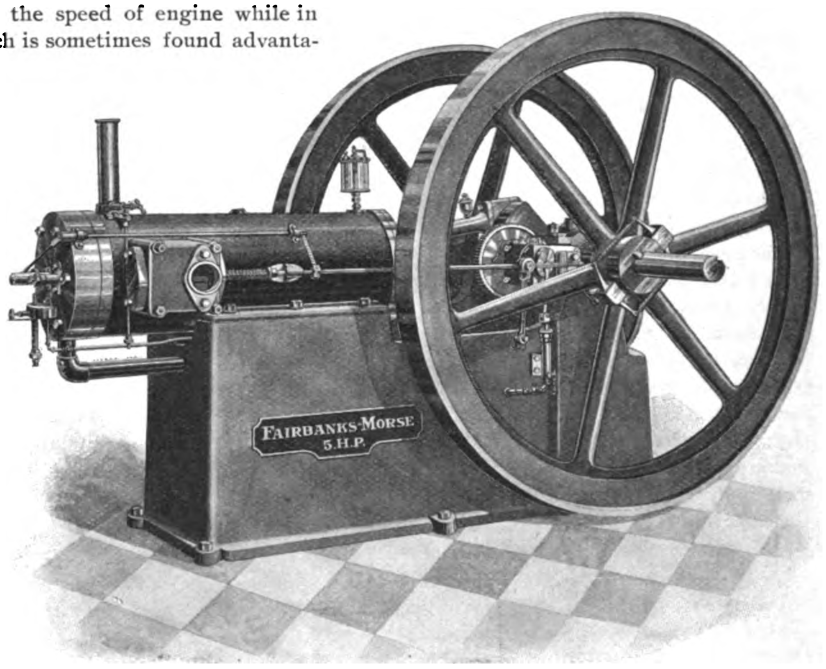


FIG. 10.—FAIRBANKS-MORSE.

In the manufacture of these engines the interchangeable system has been adopted, standard gauges, reamers, jigs and templates being used, so that any part, from a new piston ring to a new base, can be ordered with the certainty of its fitting.

The Lambert gas and gasoline engine, shown in Fig. 9, operates on the four-stroke cycle principle, there being an explosion at every second revolution. Instantaneously with the in-stroke of the piston the receiving valves open and admit into the cylinder gas or gasoline and air in a definite proportion to make an explosive charge.

These valves close just as the piston starts on its out-stroke, and the valves all being closed, the movement of the piston compresses the charge, which is ignited by the electric spark just as the piston starts on its in-stroke. The result of this ignition is the combustion of the charge previously admitted. The expansive force of this combustion is exerted against the piston, and its power is transmitted through the connecting rod and crank shaft to the flywheels, and after expending its force, it passes off through the exhaust.

The valves of the Lambert engine are of the direct acting poppet type, lifting squarely from their seats and require no oiling and little or no attention to cleaning. When used for gasoline a new form of gas vaporizer is employed, called the "mixer." A small amount of gasoline is brought in contact with the current of air as it passes through the mixer into the cylinder, where it is ignited and entirely consumed before another charge is admitted. By this simple device the makers claim to have entirely overcome the danger from gasoline, by using it raw directly from the tank, and by keeping it closely confined in an iron pipe and tank until it is admitted into the mixer and cylinder in small charges controlled by the valves.

A revolving slide rod carries the sparke cams and the governor wheel, and is driven by a noiseless spiral gear on the crank shaft. The governor is automatic and not only controls the flow of the gas or gasoline, admitting air and fuel in proper proportions and quantities, to maintain an even and economical running of the engine, but in addition shuts off the flow entirely whenever the speed of the engine is reduced below a limiting point. This prevents waste and any trouble liable to occur by a free and uninterrupted admission of the fuel. The governor is so constructed that the speed can be changed instantly while the engine is in motion.

The manufacturers of the Lambert engine prefer electric ignition to hot-tube ignition. The sparker, which is operated by an electric battery of the Edison-Lalande pattern, is a simple and compact device for making the electric spark within the cylinder. It is fitted into the head of the cylinder, and as a whole may be conveniently removed from its seat on the head of the cylinder, and through its opening the interior of the cylinder may be examined. A hot-tube igniter is made so as to be interchangeable with the sparker for those who prefer to use hot-tube ignition.

The Fairbanks-Morse gas and gasoline engine, shown in Fig. 10, is one of the best known of American types and is made in sizes from 2 to 75 HP. One of the principal features claimed by the makers is the simplicity of mechanism, the number of parts being reduced to a minimum. Modern steam practice has been followed in the location of the governor, which is attached to the flywheel, thus dispensing with gears and belts. The hot-tube igniter is used.

Referring to the gasoline engine, the oil is pumped continuously into a small brass reservoir at the engine, in which it is kept at a constant height. Air passing through a nozzle connected with this reservoir takes up sufficient oil to form a combustible mixture, the quantity of the mixture being regulated by the governor. The mixture is drawn into the cylinder on the in-stroke, and after being compressed on the out-stroke, the charge is exploded by an electric spark or hot-tube igniter, either being fitted as preferred. When an explosion is not required, the exhaust valve is held open, thus relieving the engine of the work of compression. The engine uses only two valves, which are of the poppet pattern, and both are water-jacketed. There is but one cam which, by means of a straight rod carried in suitable guides, operates the exhaust valve. The hub governor acts directly on the exhaust valve rod. For the larger sizes of engines there is a "self-starter" of extremely compact form and simple mechanism.

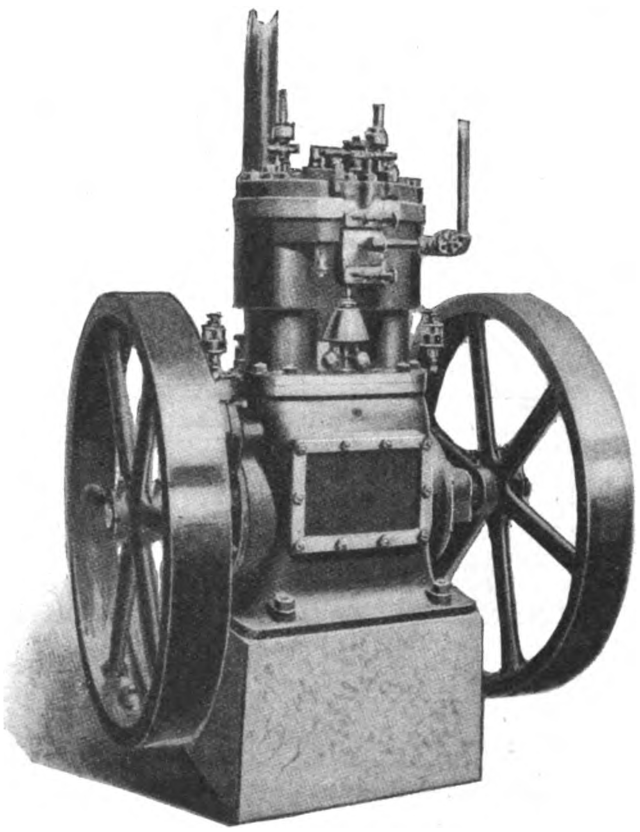


FIG. 11.—WESTINGHOUSE.

In Fig. 11 is shown the Westinghouse type of gas engine, one of the most recent of new designs. This engine embodies in a general way the features of the well-known Westinghouse steam engine, consisting of upright, self-contained construction and self-lubrication.

The valves are all of the positively actuated poppet type, which renders clogging impossible and does away with rubbing surfaces subject to wear and cutting. The valve-actuating mechanism is located under the crank case, where it is protected from dirt and grit and constantly and copiously lubricated, thus insuring a maximum of durability in these parts, which are usually considered the delicate portions of a gas engine.

The Westinghouse gas engine operates by the four-stroke cycle, but has two cylinders, thus receiving an impulse at every revolution. It regulates for changes of load by varying the amount of explosive mixture delivered at a charge, receiving an impulse at every revolution whether running fully loaded or entirely light. By this means the manufacturers claim that a smoothness of running and regulation are secured which compare very favorably with the best steam engines. The makers state that this gas engine has given excellent results when direct connected with a dynamo.

In Fig. 12 is illustrated the Bates "thermic motor," for the manufacture of which a company has recently been organized in Philadelphia. The engine forms part of the gas producer, the whole apparatus in the case of a 100-HP installation tested occupying a space of 15 ft. 9 ins. by 15 ft. 4 ins., and 13 ft. 2 ins. high.

The fuel from which the gas is generated is fed to a furnace (called "gascogen"), into which compressed air and steam are also fed, both of the latter passing through incandescent fuel and thus generating the gas used in the engine. The gas before entering the engine is passed through a dust arrester.

The cylinders of the gas engine are between the air compressor and gas furnace. There are two of these, single acting and upright, the diameter being 15¾ ins. and the stroke the same. The valve motion is obtained from a shaft extending across both cylinders, and driven by a vertical shaft geared in turn to the crank shaft. On the vertical shaft is a ball regulator which acts upon two cams controlling the valves. There are three valves on top of each cylinder, one each for the gas, air and exhaust. The gas is exhausted into a "regenerator," where it passes around tubes through which compressed air for the furnace passes before entering the latter, and also air for the cylinder exploding mixture. The engine is of the Otto four-stroke cycle type.

The upper part of the engine cylinder is used as a steam boiler to generate steam for the gas furnace. To start the engine a small auxiliary steam boiler engine, air compressor and dynamo are required, the latter for firing the charge until the firing "plates" are sufficiently hot. In a recent report by an expert to the company making the apparatus, it is stated that 109 64 lbs. of coal will generate 100 HP during one hour.

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THE AMERICAN STREET RAILWAY CONVENTION.

The Fifteenth Annual Convention of the American Street Railway Association, held at St. Louis, Oct. 20-23, was the most successful in the history of that body, more than 1000 representatives of the street railway industries being in attendance. The Association demonstrated once more the vigorous spirit with which it is animated, and in better financial shape now than ever, promises to still further add to the high prestige it already enjoys. The exhibits were very creditable to the industry, and the papers of higher quality than at perhaps any previous meeting.

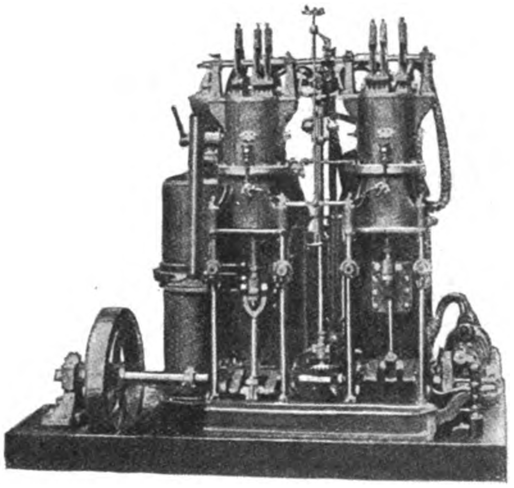


FIG. 12.—BATES.

At the election of officers, Mr. Robert McCulloch, of St. Louis, was named president, and Mr. Chas. S. Sergeant, of Boston, Mr. D. B. Dyer, of Augusta, Ga., and Mr. C. F. Holmes, of Kansas City, Mo., first, second and third vice-presidents respectively. Mr. Thos. C. Penington, of Chicago, was re-elected treasurer.

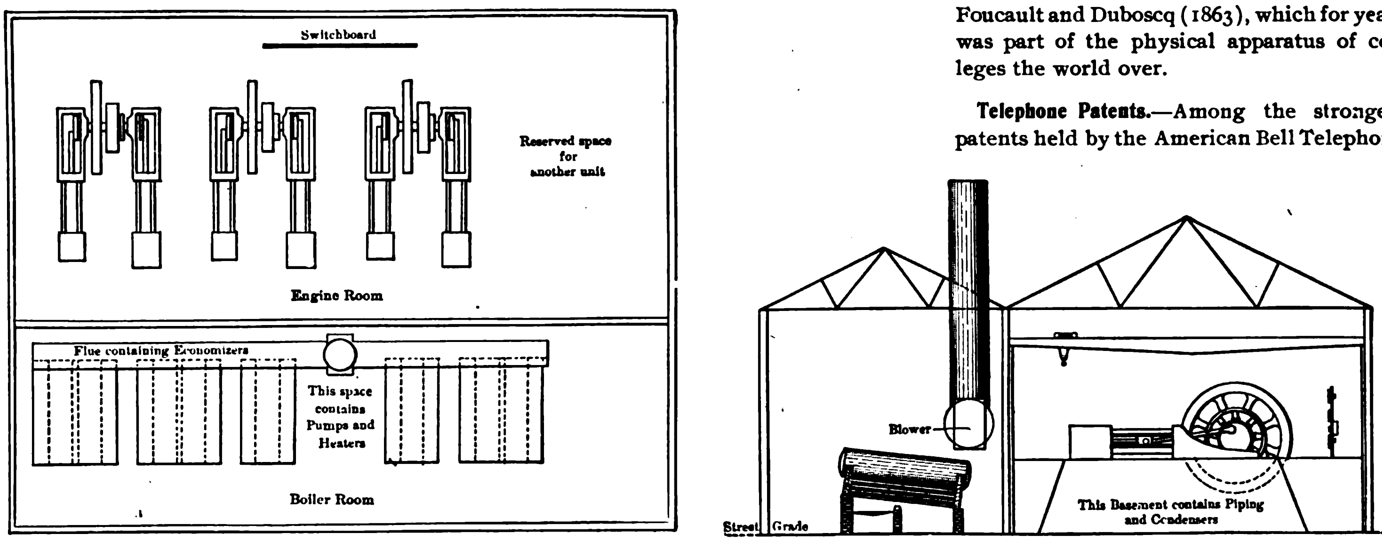
The address of the retiring president, Mr. H. M. Littell, dwelt upon the extraordinary prejudice existing against corporations, causing them to be regarded as legitimate objects of attack and spoliation, and urged a broadminded and conciliatory attitude toward the public on the part of street railway managers, in order to allay the hostile feeling. Another menace referred to is the great increase in the number of negligence suits and the size of verdicts, and Mr.

Littell considers that in the discipline of the force lies the secret of preventing the ruinous losses which follow from damage suits.

Six papers were read, two relating to questions of management, and one each to track and track joints, street railway trucks, modern overhead construction and the power house.

The paper by Mr. Robert McCulloch on "The Modern Power House," contains a complete discussion of all the factors entering, considered under the heads of location, building, steam generating apparatus and steam consuming apparatus.

Coal and ash conveyors are recommended for use in power houses handling large quantities of coal, where the coal is all delivered at the same place, as by rail or boat, but are not considered profitable where coal is delivered in small quantities in wagons and may be dumped in any part of the boiler room. Aside from acting as a smoke consumer, mechanical stokers are pronounced to have no advantage, and owing to the fact that they cannot be forced they entail a greater boiler capacity.


Switchboard
Reserved space for another unit
Engine Room
Flue containing Economizers
This space contains Pumps and Heaters
Boiler Room
Blower
Street Grade
This Basement contains Piping and Condensers

GROUND PLAN

SECTIONAL ELEVATION.

GROUND PLAN AND SECTIONAL ELEVATION OF A MODERN POWER HOUSE.

The advantages and disadvantages of different types of boilers are pointed out, and the statement made that the high efficiencies obtained in boiler tests are seldom reached in actual practice, as they usually result, not so much from excellence in design in the boiler itself as from careful and intelligent firing during the test.

The method of induced draft, whereby long smoke pipes are dispensed with and an induced draft produced by fans, is favorably commented on, the greatest advantages lying in the control it gives in governing the fires and in permitting economizers to take up practically all of the heat of the furnace gases, as none is required to maintain a draft.

As to engine piping, the best plan is pronounced to be the use of a single header divided at convenient intervals by valves, according to the size of the plant and number of units employed. A separator should be placed in the leader to every engine.

Direct connected generating units are highly favored, and vertical engines described as having the advantages of taking less space, less wear on the cylinder and a more direct strain upon the foundations. While installing compound engines where there is condensing water is termed good practice, the case is doubtful with respect to non-condensing. Self-cooling condensers are referred to in favorable terms, as well as the use of storage battery auxiliaries though the high first cost of the latter is considered a great drawback.

The general features of the design of a modern power house are shown in the accompanying illustration. The engine room and boiler room are divided by a brick wall and under different roofs; both are brick buildings, covered with an iron truss roof; the boiler room is set on the grade of the street, and the engine room ten or twelve feet above this grade, the space below the engine room being utilized for the piping and condensers; the engine and boilers are set at right angles to the wall between them, with the engines next to the boiler room, so that the piping is made as short as possible and the condensation lessened; the switchboard and feeder-board are set on the opposite side of the room from the boiler room, so that the length of the dynamo cables is equalized as much as possible. The general features of this design may be summed up as follows: It is compact, to save real estate and buildings and to minimize the number of employes and the superintendence. Large units are used for the sake of economy and to save the number of working parts. The building is, as far as possible, fireproof.

* * *

Lewis Institute.—The class-study sessions of the Lewis Institute, of Chicago, were opened for the present season on Nov. 6. Among the branches taught in evening classes are mechanical and machine drawing, structural iron work, mathematics, including the elements of the calcalus, physics and chemistry. The course, which also includes shop-work, is taught two evenings a week, throughout a session of eighteen weeks, the tuition fee being $5. Prof. Charles W. Carmen has charge of the course in physics, Mr. Fred A. Rogers that in mathematics, and Prof. Paul M. Chamberlain is in charge of drawing and machine designs.

NOTES.

The Inventor of the Arc Lamp.—A monument was dedicated Sept. 27, at Saint-Hilaire-le Bonis, France, in honor of Archereau, whom the French claim to be the inventor of the automatic arc lamp. Waite, an Englishman, in 1846, produced the first automatic mechanism for regulating the arc, consisting of wheel-work and a differential gear to turn a screw-feed one way or the other. Archereau, who was an architect of Rouen, invented his lamp in 1848 or 1850. This consisted of a solenoid in which the lower carbon magnetically floated, being counterbalanced by a weight. Prof. S. P. Thompson pronounces this lamp to be the forerunner of all arc lamps, having no clockwork and its action depending on the balance between gravity and the pull of an electromagnet. The first commercial arc lamp was that of Serrin, developed previous to 1860, the second in order being that of Foucault and Duboscq (1863), which for years was part of the physical apparatus of colleges the world over.

Telephone Patents.—Among the strongest patents held by the American Bell Telephone interest aside from those of Bell and Berliner, were two relating to the details of telephonic operation. One of them—the Roosevelt—covering the telephone hook switch expired May 27 of the present year. The other is the Watson patent which claims the combination of the induction coil with any form of a switch which severs the "call" circuit and "makes" the talking circuit, or vice versa, thus including the particular form of switch covered by the Roosevelt patent. This patent was supposed to have life until 1900, but the discovery has just been announced of a corresponding Canadian patent taken out by Watson which expired July 30, 1895. As according to United States law a domestic patent expires with the expiration of a corresponding foreign patent, the Watson patent is therefore no longer in force in this country. A representative of the American Bell interests has stated that the existence of the Canadian Watson patent was unknown until brought to their attention in the prosecution of an infringement suit, Watson himself having forgotten about it.

An Electric Farm.—Last spring one of the sensational New York newspapers published an illustrated and highly circumstantial account of an "electric farm" at Tom River, N. J., owned by one Thomas Fleming. Plows, rakers, harrows, mowers and reapers were all worked by electric motors. Weeds were killed by dragging a wire netting, heavily charged, over the field or between rows of plants, and electricity was applied to assist the growth of plants, both by means of underground currents and the arc light. Among some of the results of electric cultivation were radishes 17 ins. long, egg plants weighing 6 pounds, cabbage 2 ft. in diameter, lettuce 3 ft. tall and 2 ft. across the head, etc. The story, which was accepted in good faith by the newspaper press, was widely copied throughout the country, and we note that it has finally reached Europe. For a while after the article appeared Tom River was a Mecca for the curious, and the victims of the hoax doubtless vented many deep and loud curses against the sensational sheet which perpetrated it. They doubtless also have had their opinion greatly lowered of a profession with whose members the swarm of electrical fakes circulated in the newspaper press originate—for this, like many other similar stories, bears evidence of having been written by an educated electrical engineer.

A Fortunate Contract.—One well acquainted with the circumstances relates, apropos of the recent failure of The E. S. Greeley & Company, the following story concerning a certain telephone contract refused by that company and reluctantly accepted by another. In the early days of the Bell telephone, its management being unable to induce the former house (then L. G. Tillotson & Company) to manufacture telephone apparatus, finally arranged to that end with Mr. Charles Williams, Jr., of Boston. It soon happened that the Bell people could not make cash payments, and Mr. Williams was finally persuaded, much against his inclination, to accept a supposed equivalent in original Bell stock. Mr. Williams did his best to dispose of this stock to his customers and workmen at twenty-five cents on the dollar, but as they insisted on ready money, he at last had a trunk full of Bell stock, which he kept because he could do nothing else with it. When the public later became convinced of the value of the telephone, and local companies were everywhere formed, it is a matter of history how enormously valuable the stock became; and besides, Mr. Williams, as one of the original stockholders, received three shares for each share he had at first held. As a consequence Mr. Williams became a very rich man, and not long after retired from business.

Will There Be a Telephone War?—The celebrated seventeen-year contract between the American Bell Telephone Company and the Western Union Telegraph Company, the terms of which prevented either company from trespassing on the field of the other, expired by limitation on Nov. 1. Under the contract the American Bell has paid no less than $8,000,000 to the Western Union Company, since 1893 the annual payments having been $600,000. Owing to an ambiguity in one of the clauses of the contract, the American Bell did not entirely keep out of the telegraph field. By the Van Rysselbergh system that company is enabled to use all of its long-distance lines for telegraphic purposes without in any way interfering with telephonic transmission. Each telephone line furnishes two telegraph circuits, which latter have been leased to bankers and others as private lines. Owing to the unsettled state in which the telephone situation will remain until after the United States Supreme Court decides the Berliner case, it is not probable that either company will take any action until that decision is announced. If the Berliner patent is sustained, the American Bell would be able to enter the telegraph field with impunity. In the contrary case, that company will be much better situated to enter into telegraphic competition over a limited but rich territory than the telegraph company will be to compete in the telephone business.

The Electric Furnace.—M. Henri Moisson, the distinguished French electro-metallurgist, delivered a lecture in the College of Physicians and Surgeons, at New York, on Oct. 27, during which, with the assistance of Mr. C. O. Mailloux, he experimentally illustrated some of the capabilities of the electric furnace. The furnace used at the lecture consists of a block of chalk about 10 inches square and 7 inches deep, having a central conical cavity about large enough to contain an egg. Through opposite sides are openings into the cavity for carbon electrodes; when in operation a small crucible rests on the bottom of the cavity beneath the electrodes, and the top is covered by a slab of lime, whose lower surface is somewhat hollowed over the crucible like the roof of a reverberatory furnace. The material to be subjected to the intense heat of the furnace is placed in the crucible, the cover put in position and the current turned on. One of the experiments was the manufacture of diamonds, during which a current of 250 amperes at 60 volts was maintained for fifteen minutes. In the crucible had been placed some iron borings and very pure carbon, and at the end of the experiment the crucible and its contents were plunged into water. The diamonds thus made are very small in size and of little brilliancy, but M. Moisson is confident that commercial results may be achieved in the future. The theory of the process is that the liquified carbon imprisoned in the mass of the iron crystallizes on account of the enormous pressure to which it is subjected when the contents of the crucible are suddenly cooled.

What Does it Mean?—According to an account published in some of the New York City newspapers, a serious difference of opinion exists between two factions of the Metropolitan Traction Company of that city, as to the relative merits of the underground trolley and compressed air systems of street traction. Mr. Wm. C. Whitney is represented as among those favoring the latter, while Mr. John D. Crimmins champions the electrical system. In this connection it is interesting to recall that early in the spring of the present year the Metropolitan Company issued an official statement highly extolling the Budapest electrical system in operation on Lenox Avenue, which was stated to have withstood excellently the severe test offered by the worst season of the year. Several months later, however, another statement was issued in which the Lenox Avenue system was discredited, the terms of the statement being contradictory to those of the earlier one without giving any satisfactory reasons for the change. Mr. Crimmins is stated to adhere to the views expressed in the earlier statement, believing that the Lenox Avenue system is an entire success. Among the reasons that have been offered to account for the opposition to the underground trolley, are that, by an acknowledgement of its success, the chances of introducing the overhead trolley north of the Harlem and on cross-town lines would be minimized; that traction companies in other cities in which Metropolitan Traction capitalists are interested, fear the effect on municipal authorities of the success of the underground trolley; and that the son-in-law of Mr. Whitney is interested in the adoption of the compressed air system.

Supreme Court Opinions.—In a recent address Justice Harlan of the United States Supreme Court explains that Court's method of procedure in the consideration of cases brought before it, which information may be of interest to our readers at the present time in view of the great importance of the Berliner case recently argued before that Court. Each Justice is furnished with a printed copy of the record and with a copy of each brief filed, and each one examines the records and briefs at his chambers before the case is taken up for consideration. The cases are thoroughly discussed in conference—the discussion in some being necessarily more extended than in others. The discussion being concluded—and it is never concluded until each member of the court has said all that he desires to say—the roll is called, and each Justice present and participating in the decision votes to affirm, reverse, or modify, as his examination and reflection suggest. The Chief Justice, after the conference, and without consulting his brethren, distributes the cases so decided for opinions. No Justice knows, at the time he votes in a particular case, that he will become the organ of the court in that case; nor does any member of the court ask that a particular case be assigned to him. The next step is the preparation of the opinion by the Justice to whom it has been assigned. The opinion, when prepared, is privately printed, and a copy placed in the hands of each member of the court for examination and criticism. It is examined by each Justice and returned to the author, with such criticisms and objections as are deemed necessary. If these objections are of a serious kind, affecting the general trend of the opinion, the writer calls the attention of the Justices to them that they may be passed upon. The author adopts such suggestions of mere form as meet his views. If objections are made to which the writer does not agree, they are considered in conference, and are sustained or overruled as the majority may determine. The opinion is reprinted so as to express the final conclusions of the court, and is then filed. When an opinion of the court is on file and published, it may be taken as expressing the deliberate views of the court based upon a careful examination of the records and briefs by each Justice participating in the judgment.

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How to Compound a Dynamo.

In a previous issue a method was given whereby a shunt dynamo already in use could be compounded to take care of armature drop, or overcompounded to also provide for line drop. In this issue are two further articles on the subject, giving other methods of attaining the same end, both of which are models of simplicity. The method of Prof. McKissick, like that described in a previous issue, involves the use of a trial coil, and also of a variable resistance and outside source of current, but otherwise is extremely simple in its details. That of Mr. Poole is particularly convenient of application, as it merely requires two voltmeter readings, no trial coil or external source of current being necessary. It is necessary, however, to determine the resistance of the shunt coil, but this, as shown, can be done to a near enough approximation by simple measurements. Either method will enable an electrician to compound his dynamo, if shunt wound, without any probability of error, and at such a small expenditnre of labor and material, that he should not hesitate to take advantage of the opportunity thus offered to modernize his machine.

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Isolated Electric Plants for Country Residences.

Elsewhere we print three articles on the subject of isolated plants for country residences, which will repay careful perusal by our readers. Two of the articles refer to plants in operation, giving the various details of installation and operation, and the third lays down in general form the principles which should be observed in the design and installation of such plants, and also gives valuable information on the care and management of storage batteries. It should be remarked that while with a properly designed plant of the above character expert attendance is not necessary in its operation, it should be inspected at definite intervals by an expert. In justice to themselves, consulting engineers and others drawing up specifications for a plant, should include a clause providing for such inspection. Otherwise it is likely to be not done, whether through neglect, supposed economy or reluctance on part of the attendant to subject his stewardship to criticism.

As part of a country residence electric lighting plant, a storage battery should be considered indispensable. A plant without this appendage would, almost undoubtedly, be found in time so unsatisfactory as to cause it to be thrown out, or lead to the addition of a battery under circumstances as to proper installation, less favorable than if it were included in the original plans. One of the advantages of the addition of a storage battery that should not be lost sight of, is that it involves a generating plant of smaller capacity than if the lighting were dependent on the dynamo alone. By connecting the lamps on two circuits, these can ordinarily be run together from the battery, and separated on special occasions when there is an abnormal demand for light, one circuit being then fed direct from the dynamo. The addition of a wattmeter is also advisable, which may be so connected that when switched on the charging circuit, a shunt diverts a portion of the current corresponding in amount to the storage loss, thereby rendering the battery charging and discharging readings equivalent to each other.

◆

The American Street Railway Association.

The recent St. Louis Convention of the American Street Railway Association was in several respects the most successful yet held by the body. The attendance was the largest in its history and the papers read were of a higher average than at any previous meeting. The discussions, it is true, were limited, but this is perhaps to be ascribed to the discomforts of the meeting room rather than to any lack of interest in the subjects treated. One of our contemporaries has very wisely said that "the genuine business of an association of this character—the papers and the discussion of problems of practical importance to members—must always be the real foundation of the convention structure," and therefore the first care in arranging for a meeting should be the selection of a hall best adapted to further these ends. Heretofore, however, this feature has been subordinated to the trade exhibition part of the programme. The selection of a suitable hall to contain the exhibits has been the first consideration, which has usually involved more or less of a sacrifice of what should be the main object of the convention, as outlined above.

The papers read before the Convention and the discussions that took place were of distinctly more conservative character than in the case of the proceedings of the purely electrical associations. The absence is also to be remarked of leading electrical and mechanical engineering authorities, whose presence adds so much to the interest of the proceedings of the latter. While it is true that the membership of the Association are business rather than professional men, yet they could nevertheless derive much advantage from opinions of scientific or engineering authorities expressed in papers or drawn out during discussions, concerning disputed points or new developments affecting the street railway industry. For example, the subjects of the relative economy in street railway service of simple and multiple steam working, the application of alternating currents to railway traction, the advantages of storage battery auxiliaries, etc., with Steinmetz, Bell, Emery, Mailloux, Scott, Lloyd and others of similar competency in the audience to call on for information, would undoubtedly largely increase both the value and interest of the proceedings. Though the subjects may be scientific in character and even highly so, it should be possible to have their practical aspects, under the questioning of railway managers, thoroughly elucidated. It is to be hoped that the Association may at future meetings secure a larger attendance of the element referred to, which is always willing to place itself at the disposal of bodies representing the industrial interests of their profession.

The Berliner Patent.

The suit of the Unites States *vs.* the American Bell Telephone Company, *et al*, reached a hearing before the Supreme Court of the United States on Monday, Nov. 9. The object of this now famous suit is the cancellation of the 1891 Berliner transmitter patent, owned by the American Bell Telephone Company. This patent was applied for by Emile Berliner on June 4, 1877, and after lingering in the Patent Office for more than fourteen years, was finally issued on Nov. 17, 1891, to the American Bell Telephone Company, assignee of Berliner. It is claimed that this patent covers broadly and fundamentally the apparatus necessary for the transmission of speech by means of a varying current transmitter. In other words, that it is a fundamental microphone patent, covering all forms of transmitters which can be used, and have been used, for the successful transmission of speech commercially. We refer our readers to another column containing a more extended discussion of this noted case.

The importance of the decision of the Supreme Court cannot be overestimated, not only on account of the vast interests at stake—the monopoly of the American Bell Telephone Company on the one hand, and the interests of the public on the other—but also on account of the still greater question at issue—an attack, according to Government Counsel, upon the equity of our patent laws. The Supreme Court is, in fact, asked to decide whether a great corporation, or an individual, can successfully prolong its monopoly under a patent granted, by delaying an apparatus patent fourteen years in the Patent Office before its issue, in the meantime reaping the exclusive profits from the use of this identical apparatus under the protection of a method patent, thus actually prolonging the monopoly to more than thirty-two years.

The case has already passed through the Circuit Court, District of Massachusetts, where Judge Carpenter adjudged in favor of the United States; and through the Circuit Court of Appeals of the same District, on appeal by the American Bell Telephone Company, where Judge Carpenter was overruled in favor of the appellants. The United States has now brought the case to the Supreme Court. As stated elsewhere, the main points at issue are the legality of the delays in the Patent Office, and the patentability of the principle of the transmitter in view of the 1880 receiver patent, which was on identically the same apparatus of the later patent, but under another name. Should the Berliner patent be declared void, the art of telephony will be free, aside from patents relating to details of exchanges. Next in importance to the patent now in suit was that of Watson, and through the astonishing discovery a few days ago of a lapsed Canadian patent, this is now free to public use.

Gas Engines.

The opinion is growing that the gas engine is destined to play in the future a large part in the generation of power. As remarked elsewhere, its merits have been much more appreciated in Europe than in this country, there having been 15,000 sold there during the first ten years of the life of the Otto patent, while at present one manufacturer in England alone turns out sixty engines per week. In Great Britain and Germany a number of central electric lighting stations use the gas engine as a prime mover, and it was adopted for the new station at Belfast, Ireland, upon the recommendation of no less an authority than Prof. Kennedy. More recently the Danbury (Conn.) central station followed European practice in this respect, having installed three 100-HP gas engines to run the electrical machinery. Whether justly or otherwise, the business management of the gas engine industry in this country has been the subject of some criticism as the cause of the little progress made, and we are informed that an order for a gas engine was recently placed in England on account of dissatisfaction on this score.

The comparatively small period of time since the modern gas engine was invented is not, we believe, generally realized. Though the principle dates back definitely to a suggestion of Huyghens in 1680, and was experimented with in 1690 by Papin, the inventor of the steam engine, it was not put to practical use until 1860, while all modern gas engines only date from the invention in 1876, by Otto, of the four-stroke cycle principle, and the recognition of the necessity of compression to secure efficiency. In other words, the gas engine industry of to-day was nearly contemporaneous in birth with that of arc lighting and telephony, and the machine itself is antedated by the continuous current dynamo.

That the coal economy of the gas engine is very high in larger sizes has been shown by numerous tests. In a test made several years ago by Prof. H. W. Spangler, of the University of Pennsylvania, of a 100-HP four-stroke cycle engine, an indicated horse power was developed on .83 lb. of combustible per hour, the efficiency of the gas producer being 69.1 per cent. or about the same as that of a steam boiler. This coal consumption efficiency of an actual gas engine is as great if not greater, than we can ever expect to attain with the steam engine, even under ideal conditions as to steam working. As to the thermic efficiency, that of the gas engine is, of course, greatly in excess of the highest that is possible with the steam engine, whose upper limit of possible temperature is much below that obtaining in any of the present gas engines.

The working efficiency of the gas engine, or its efficiency as a simple machine, is by no means as low as might be thought on account of the considerable heat losses in the water jacket and exhaust. A 17-HP gas engine, tested under the auspices of the English Society of Arts, transformed 21 per cent. of the heat energy of the gas used into mechanical work. The thermic efficiency of the same engine, or the ratio between the entire quantity of heat energy utilizable were the engine a perfect one having no preventable losses, and the total heat energy of the gas used, was 40 per cent. The working efficiency, or the ratio between these percentages was therefore 53 per cent., which is a fair figure for the steam engine; a gas engine working efficiency as high as 67 per cent. has been obtained, which is perhaps superior to that of any steam engine.

In a test made by Prof. Unwin, of the heat units supplied to a 4-HP engine, it was calculated that 20 per cent. were accounted for by the indicator, 20 per cent. were carried off by jacket water and 60 per cent. passed away in the exhaust gases, in radiation, etc. As the perfect efficiency of the same engine is about 40 per cent., there was thus only a possible saving of 20 per cent. Since there must be heat losses in the cooling water and exhaust gases, and as the superior temperature limit in the gas engine is permanently fixed by dissociation, it will be seen that when the thermic efficiency gets beyond 20 per cent. the margin of saving becomes small. A thermic efficiency of 41 per cent. has been recorded, corresponding to a working efficiency of 67 per cent. and a consumption of 17 cu. ft. of gas per hour, which may be accepted as very near the best performance that can be expected from the gas engine. As this, however, corresponds to about three-fourths of a pound of combustible per hour, this conclusion is by no means discouraging,

HOW TO MAKE A WIMSHURST INFLUENCE MACHINE.

This machine is the easiest of all static machines to make, and one of the most satisfactory in its results. It is practically independent of the weather conditions. If made as described herein, the machine will be capable of giving a continuous stream of two inch sparks, and will have sufficient power to excite a small Crookes tube, provided that the terminals of the tube are very near together.

The first and most difficult part of the work is to shape the glass disks. There are two of these and they are made exactly alike. They are to be twelve inches in diameter, and have a ¾ in. hole in the center. Inasmuch as many are not familiar with the cutting of glass into such a shape a few hints will be useful.

Select a piece of window glass of the cheap green variety. Better grade glass contains lead and is less suitable. The hole in the center should be bored first. Prepare a solution of camphor in turpentine and use it to keep the boring tool moist. The boring tool may be made of a rat tail file. The end should be snapped off and the boring performed with a twisting motion of the hand, care being taken to keep the file moist. Patience is necessary and when the hole gets so deep that it is nearly ready to break through, it is necessary to proceed with extreme caution. Once safely through the hard part of the work is done. The hole must now be cautiously filed to size, still using the camphor and turpentine as a moistener. A mark to work by may be made by gluing a piece of cardboard carrying a hole of proper size on to the side of the glass.

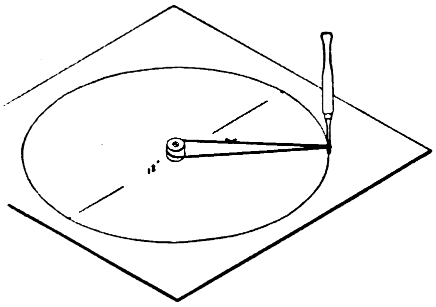


FIG I.—METHOD OF CUTTING GLASS DISKS.

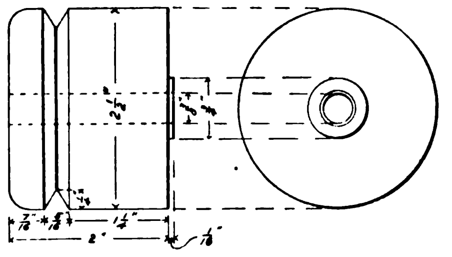


FIG. 2.—HUBS OF MACHINE.

Having completed the hole, it remains to trim the edge of the glass into circular form. This is a comparatively easy matter. Erect on a flat surface a little pillar of wood ¾ in. in diameter. Place the glass over this so that the pillar protrudes through the hole. Prepare a loop of string of such length that when it is looped around the pillar as in Fig. 1, the glazier's diamond will swing in a twelve inch circle. Be sure to use a glazier's diamond, as the use of a cheap wheel glass cutter would be likely to spoil all the work in boring the holes. It may be better to have a glazier snap off the glass if the operator is not experienced in such work.

Prepare the wooden hubs as shown in the drawing (Fig. 2). Bush them with a brass tube ⅝ in. in internal diameter. These hubs are secured to the glass disks with cement. Major's cement or marine glue is excellent, and bicycle tire cement answers very well. After this is done the disks should be thoroughly shellaced with filtered shellac, and allowed to dry. In the meantime other parts may be prepared.

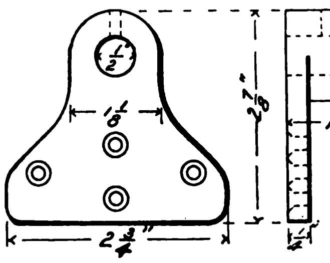


FIG. 3.—SIDE SUPPORTS.

The side supports are of wood, and hard maple is preferable. They are finished to the size shown in the drawing (Fig. 3) and the holes in the upper part are of such size as to tightly fit the ⅝ in. shaft they support.

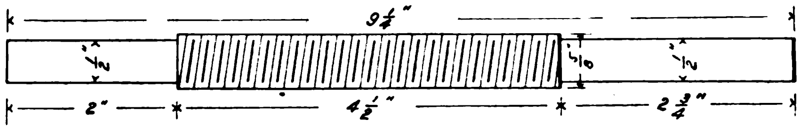


FIG. 4.—SHAFT.

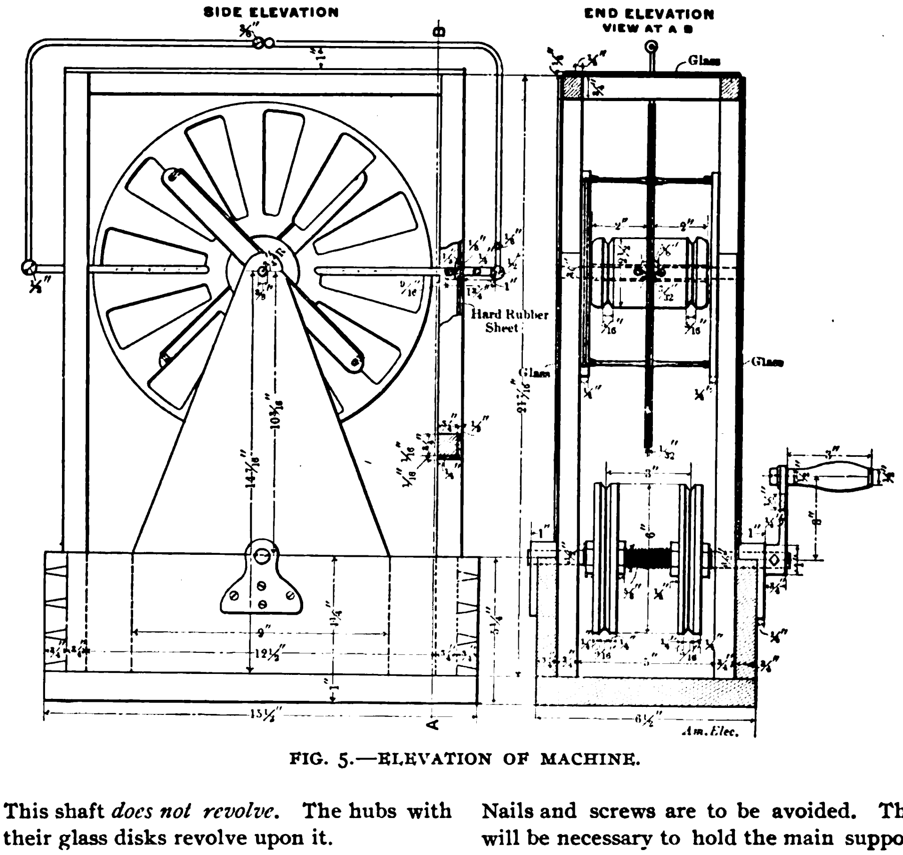


FIG. 5.—ELEVATION OF MACHINE.

This shaft *does not revolve*. The hubs with their glass disks revolve upon it.

The shaft carrying the two wheels is the only part that requires the services of a metal lathe; should this not be available, the metal parts can be made for a small sum by a machinist from the figured drawings in the article. In its largest diameter this shaft is ⅝ in., and all of this part is threaded. The ends are turned down to ½ in. journals, as shown in the drawing. One of these journals is sufficiently long to pass completely through its bearing and carry a small crank. The shaft is shown in Fig. 4, and the bearing in Fig. 5. This latter may be cast in brass from a wooden pattern.

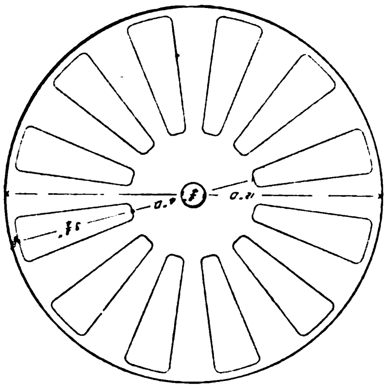


FIG. 6.—ARRANGEMENT OF SECTORS ON DISKS.

The remainder of the wooden parts of the machine may be built and assembled as per drawing. They should be of hard, well seasoned maple, and thoroughly varnished. The parts should be put together with glue. Nails and screws are to be avoided. They will be necessary to hold the main supports of the machine in place and in some other places where the strain is great, but they should be used sparingly. The whole should be given a coat of shellac varnish.

When the disks are thoroughly dry they are ready to receive the tinfoil sectors (Fig. 6). There are twelve of these to each disk, and they are secured in place at equal angular intervals thereon. Follow the drawings closely and no mistakes can be made.

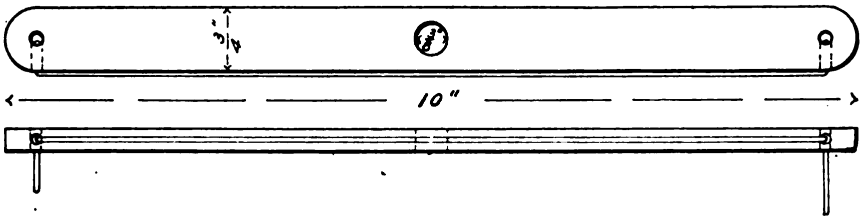


FIG. 7.—YOKE FOR CONNECTING OPPOSITE SECTORS.

Shellac is to be used as an adhesive, and the edges of the sectors are to be covered with varnish, overlapping at least $\frac{1}{16}$ in., to prevent dissipation of charge. This completes the disks.

Mounted on the disk shaft with a tight driving fit are two pieces of hard rubber, (Fig. 7). These carry stiff wires, on the ends

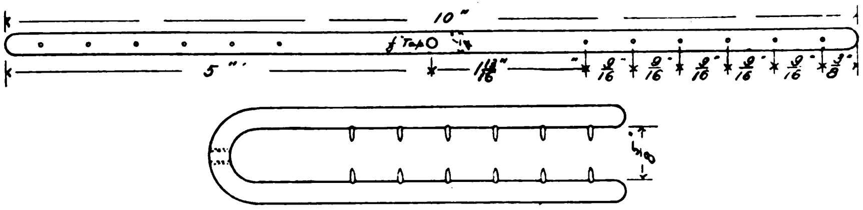


FIG. 8.—COMB.

of which are light brushes made of tinsel. Each rubber piece carries two brushes, one at each end, and the two brushes are electrically connected. They are adjusted so as to just touch the sectors as the disks rotate and thereby put opposite sectors in contact. Their angular position can be easily adjusted

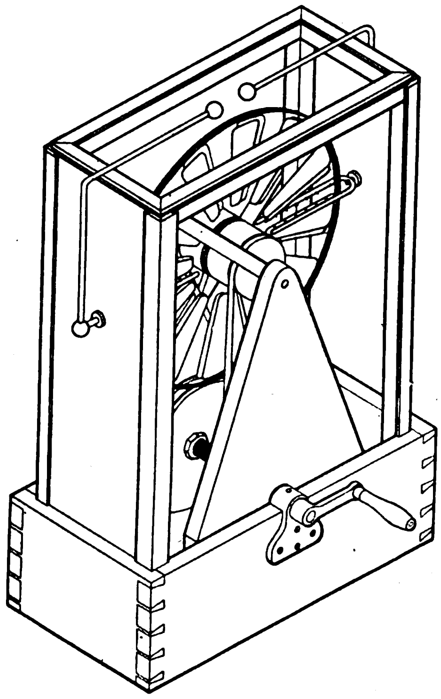


FIG. 9.—GENERAL VIEW OF MACHINE.

to the position where the working of the machine is found to be best.

Two U-shaped combs collect the output from the disks. They are conveniently made by drilling a ¼ in. brass rod with holes at suitable intervals and soldering pin points into the holes. The combs may then be bent to shape. In Fig. 8 is illustrated the method of forming the comb. The sides of the enclosure are of hard rubber and serve to support the combs. A small binding post may be threaded into a hole at the curvature of the **U** of the comb, and with the aid of a few washers the comb is neatly and securely held. See general view, Fig. 9.

The other sides of the enclosure are of glass, both on account of its insulating quality and transparency. The plates are held in place by pieces of rabbeted moulding mitered on to the sides of the upright pillars. If the construction is followed out as shown in the cuts, the glass and rubber plates will lift like a window sash and render the machine completely accessible. The disks are driven in opposite directions by means of a straight and a crossed belt from the shaft below. In making the metal parts of the machine, all sharp corners are to be avoided with great care, for at every corner the charge disappears and leaks away.

The person building this machine must not be disappointed if at first trial it does not work at once. If the shellac is the least particle damp the machine will refuse to generate, but once dry it will generate without failure thereafter. The tinsel brushes must make positive contact with the sectors or the machine will not start. They must be so adjusted as to touch opposite sectors simultaneously. The best working angle for the tinsel brushes is 45° with the horizontal. The disks should rotate from the comb towards the nearest tinsel brush.

The entire cost of the machine, assuming that all of the metal working that requires the use of machine tools is hired out, should not exceed $5.

Clouds and Horse Power.

A calculation is given in a Bulletin of the United States Weather Bureau showing the immense quantity of energy expended in the formation of clouds. It is estimated, on the basis of the annual fall of water as rain or snow in the United States, that the work done in raising the rainfall to the clouds is equivalent to 1,920,000,000 continuous HP, or the work of 5,000,000,000 horses toiling ten hours a day—perhaps a thousand times as many horses as there are in the United States.

AMERICAN TELEPHONE PRACTICE.

HISTORY AND THEORY OF THE BATTERY TRANSMITTER.

BY KEMPSTER B. MILLER.

It has been shown that in order to transmit speech by electricity, it is necessary to cause an undulatory current to flow in the circuit over which the transmission is to be effected, and that the strength of this current must at all times be in exact accordance with the vibratory movements of the body producing the sound.

Bell's transmitter was used as the generator of this current; as a dynamo, in fact, the energy for driving which was derived from the sound waves set up by the voice. The amount of energy so derived was, however, necessarily very small and the current correspondingly weak, and for this reason this was not a practical form of transmitter, except for comparatively short lines.

Elisha Gray devised a transmitter which, instead of generating the undulatory current itself, simply served to cause variation in the strength of a current generated by some separate source. He accomplished this by mounting on his vibrating diaphragm, *D* (Fig. 1), a platinum needle, *n*, the point of which was immersed in a fluid of rather low conductivity, such as water. The variable distance to which the needle was immersed in the fluid, due to the vibration of the diaphragm, caused changes in the resistance of the path through the fluid, and corresponding changes in the strength of the current set up in the circuit by the battery, *B*. Instead of making and breaking the circuit, as did the transmitter of Reis, this instrument simply caused variations in the resistance of the circuit, and thereby allowed a continuous but undulatory current to pass over the line. The variations in this current conformed exactly with the sound waves acting upon the diaphragm, and were, therefore, capable of reproducing all the delicate shades of timbre, loudness and pitch necessary in articulate speech.

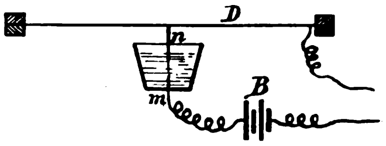


FIG. 1.—GRAY'S VARIABLE RESISTANCE TRANSMITTER.

Gray thus established the principles upon which all successful battery transmitters are based, but it was not long before a much better means was devised for putting them into practice.

In 1877, Emile Berliner, of Washington, D. C., invented a transmitter depending upon a principle previously pointed out by the French scientist, Du Moncel, that if the pressure between two conducting bodies forming part of an electric circuit be increased, the resistance of their point of contact will be diminished, and conversely, if the pressure between them be decreased, a corresponding increase of resistance will result.

Berliner's transmitter is shown in Fig. 2, in which *A* is the vibratory diaphragm of metal, against the center of which rests the metal ball, *C*, carried on a thumb-screw, *B*, which is mounted in the standard, *d*. The pressure of the ball, *C*, against the plate, *A*, can be regulated to any desired degree by turning the thumb-screw. The diaphragm and ball form the terminals or electrodes of a circuit, including a battery and receiving instrument. When the diaphragm is vibrating, the pressure at the point of contact, *a*, becomes greater or less, thus varying the resistance of the contact and causing corresponding undulations in the current flowing.

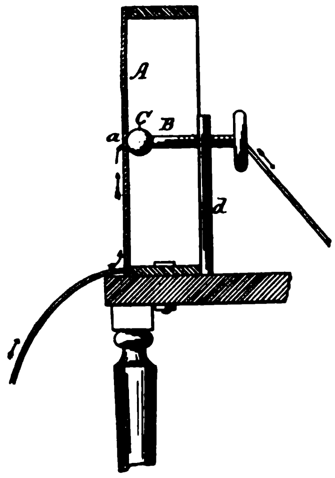


FIG. 2.—BERLINER'S TRANSMITTER.

Soon after this, Edison devised an instrument depending upon the peculiar property possessed by carbon of varying its resistance with changes of pressure. Edison's first type of carbon transmitter consisted simply of a button of compressed plumbago bearing against a small platinum disk secured to the diaphragm. The plumbago button was held against the diaphragm by a spring, the tension of which could be adjusted by a thumb-screw.

A form of Edison's transmitter devised by George M. Phelps, of Brooklyn, in 1878, is shown in Fig. 3. The transmitting device proper is shown in the small cut at the right of this figure, and is enclosed in a cup-shaped case formed of the two pieces, *A* and *B*, as shown. Secured to the front of the enlarged head, *e*, of the adjustment screw, *E*, is a thin platinum disk, *F*, against which rests a cylindrical button, *G*, of compressed lamp black. A plate of glass, *I*, carrying a hemispherical button, *K*, has attached to its rear face another platinum disk, *H*. This second platimum disk rests against the front face of the carbon disk, *G*, and the button, *K*, presses firmly against the center of the diaphragm, *D*. The plates, *F*, and, *H*, form the terminals of the transmitter, and as the diaphragm, *D*, vibrates, it causes variations in the pressure, and corresponding changes in the resistance of the carbon block, *G*, thus producing the desired undulations of current.

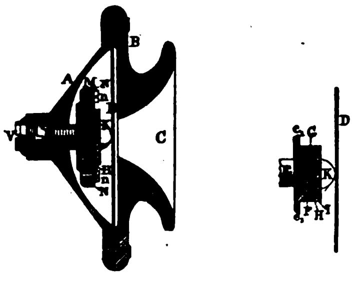


FIG. 3.—PHELPS-EDISON TRANSMITTER.

Professor David B. Hughes made the next valuable contribution tending toward the perfection of the battery transmitter. By a series of interesting experiments, he demonstrated conclusively that a loose contact between the electrodes, no matter of what substance they are composed, is far preferable to a firm strong contact. The apparatus used in one of his earlier experiments, made in 1878, is shown in Fig. 4, and consists simply of three wire nails, of which *A* and *B* form the terminals of the circuit containing a battery and a receiving instrument. The circuit was completed by a third nail, *C*, which was laid loosely across the other two. Any vibrations in the air in the vicinity caused variations in the intimacy of contact between the nails, and corresponding variations in the resistance of the circuit. This was a very inefficient form of transmitter, but it demonstrated the principle of loose contact very cleverly.

It was soon found that carbon was by far the most desirable substance for electrodes in the loose contact transmitter, and nothing has ever been found to even approach it in efficiency.

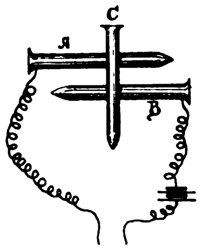


FIG. 4.—HUGHES' NAIL TRANSMITTER.

Another form of transmitter devised by Hughes, and called by him the microphone, is shown in Fig. 5. This consists of a small pencil of gas carbon, *A*, pointed at each end, and two blocks, *B B*, of carbon fastened to a diaphragm or sounding board, *C*. These blocks are hollowed out, as shown, in such a manner as to loosely hold between them the pencil, *A*. The blocks, *B B*, form the terminals of the circuit. This instrument, though crude in form, is of marvelous delicacy and is well termed microphone. The slightest noises in its vicinity, and even those incapable of being heard by the ear alone, produce surprising effects in the receiving instrument. This particular form of instrument is, in fact, too delicate for ordinary use, as any jar or loud noise will cause the electrodes to break contact and produce deafening noises in the receiver. Nearly all carbon transmitters* of to-day are of the loose contact type, this having entirely superseded the first form devised by Edison, which depended on the actual resistance of a carbon block being changed under varying pressure.

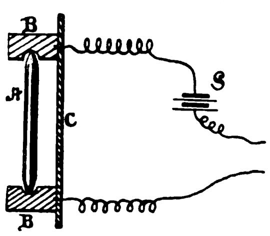


FIG. 5.—HUGHES' MICROPHONE.

But one radical improvement now remains to be recorded. In 1881, Henry Hunnings, devised a transmitter wherein the variable resistance medium consisted of a mass of finely divided carbon granules held between two conducting plates. His transmitter is shown in Fig. 6. Between the metal diaphragm, *A*, and a parallel conducting plate, *B*, both of which are securely mounted in a case formed by the block, *D*, and a mouthpiece, *F*, is a chamber filled with fine granules of carbon, *C*. The diaphragm, *A*, and the plate, *B*, form the terminals of the transmitter, and the current from the battery must therefore flow through the mass of granular carbon, *C*. When the diaphragm is caused to vibrate by sound waves, it is brought into more or less intimate contact with the carbon granules and causes a varying pressure between them. The resistance offered by them to the current is thus varied, and the desired undulations in the current produced. This transmitter instead of having one or more points of variable contact, is seen to have a multitude of them. It can carry a larger current without heating and at the same time produce greater changes in its resistance, than the forms previously devised, and no sound can cause a total break between the electrodes. These and other advantages have caused this type in one form or another to largely displace all others. Especially is this true on lines of great length.

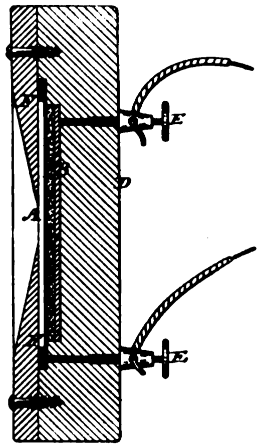


FIG. 6.—HUNNINGS' GRANULAR TRANSMITTER.

Up to this time all transmitters, together with the receiver and battery, had been put directly in circuit with the line wire. With this arrangement the changes produced in the resistance by the transmitter were so small in comparison with the total resistance of the circuit, that the changes in current were also very small and produced but little effect on the receiver. Edison remedied this difficulty by using an induction coil in connection with the transmitter. The credit of this improvement, however, should be given largely to Gray, for in 1875 he had used an induction coil in connection with his harmonic telegraph transmitter, and Edison merely substituted a telephone transmitter in the circuits used by Gray.

The induction coil used then and now is made as follows: Around a core formed of a bundle of soft iron wires is wound a few turns of comparatively heavy insulated copper wire. Outside of this and entirely separate from it, is wound another coil, consisting of a great number of turns of fine wire, also of copper and insulated. The inner coil is called the primary, the outer the secondary. In telephone work it is now almost universal practice to place the transmitter, together with the battery, in a closed circuit with the primary of the induction coil, and to place the secondary directly in circuit with the line wire and receiving instrument. This is shown in Fig. 7, in which *T* is a transmitter, *B* a battery, *P* and *S* the primary and secondary, respectively, of an induction coil, *L L′* the line wires, and *R* the receiving instrument. It is well to state here that the usual way of indicating the primary and secondary of an induction coil, in diagraphic representation of electrical circuits, is by an arrangement of two adjacent zigzag lines, as shown in Fig. 7. A current flowing in the primary winding of the induction coil produces a field of force in the surrounding space, and any changes caused by the transmitter in the strength of the current produce changes in the intensity of this field. As the secondary winding lies in this field, these changes will, by the laws of Faraday and Henry, cause currents to flow in the secondary winding and through the line wire to the receiving instrument. In all good induction coils the electromotive forces set up in the secondary coils bear nearly the same ratio to the changes in electromotive force in the primary coil, as the number of turns in the secondary bears to the number of turns in the secondary bears to the number of turns in the primary.

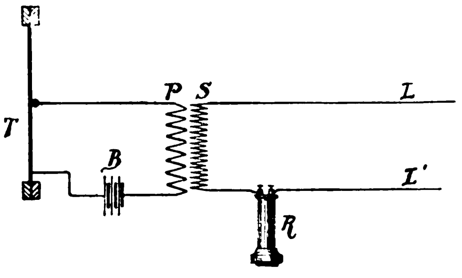


FIG. 7.—TRANSMITTER WITH INDUCTION COIL.

The use of the induction coil with the transmitter accomplishes two very important results: First, it enables the teansmitter to operate in a circuit of very low resistance so that the changes in the resistance produced by the transmitter bear a very large ratio to the total resistance of the circuit. This advantage is well illustrated by contrasting the two following cases:

Suppose a transmitter capable of producing a change of resistance of one ohm be placed directly in a line circuit whose total resistance is 1000 ohms; a change in the resistance of the transmitter of one ohm will then change the total resistance of the circuit one one-thousandth of its value, and the resulting change in current flowing will be but one one-thousandth of its value. On the other hand, suppose the same transmitter to be placed in a local circuit as above described, the total resistance of which circuit is five ohms; the change of one ohm in the transmitter will now produce a change of resistance of one-fifth of the total resistance of the circuit and cause a change of one-fifth of the total current flowing. It is thus seen that fluctuations in the current can be produced by a transmitter with the aid of an induction coil which are many times greater than those produced by the same transmitter without the coil.

The second advantage is that by virtue of the small number of turns in the primary winding and the large number in the secondary winding of the induction coil, the currents generated in the secondary are of a very high voltage as compared with those in the primary, thus enabling transmission to be effected over much greater length of line and over vastly higher resistances than was formerly the case. Without the induction coil long distance telephony would be impossible.

INTERIOR WIRING.

THE THREE-WIRE SYSTEM.

If the positive terminal of an incandescent dynamo is connected to the negative terminal of a similar machine, the two are said to be in series and the available voltage at their terminals is equal to the sum of the voltages of the two machines. In this case, assuming the system to be one of 110 volts, this potential difference would be twice that, or 220 volts. If we should connect across the 220-volt terminals a 110-volt lamp, the latter would illuminate to a dazzling briliancy for a few moments and then burn out, or it might even explode, throwing glass in all directions. If two lamps in series are connected across these terminals, they will burn at their normal brilliancy provided they are exactly alike, and it is easy to see that a system could be devised with a voltage of 220, by using two lamps in series instead of one as diagrammatically indicated in Fig. 1. Such a system would have a number of disadvantages. If one filament should fail, two lamps would be extinguished. If both lamps were not of exactly the same resistance, the voltage would not divide equally between them, and one would be too bright while its mate would be too dim. Thus the one would have a foreshortened life and the other would burn at a very uneconomical efficiency. Two lamps must thus be used.

This system has the important advantage that it requires only one-fourth of the copper that an ordinary 110-volt system requires. This is best demonstrated by a simple problem. Suppose that sixty lamps at a distance of one hundred feet from the bus-bars are to be fed with a loss in the wires of five per cent. of the total energy, the normal voltage of the system being 110. Applying the well known rule,

$$\frac{\text{Line loss in volts}}{\text{Lamp feet}} = \frac{5.5}{6000} = .000917 \text{ ohm}$$

per foot for the proper wire.

With the 220 volt system, each lamp sends its current through another before returning it to the bus-bar and thus .5 ampere suffices for two lamps instead of 1 as with the other system; thus only half the current is to be transmitted at double the voltage. Now as to the energy lost in transmission. In this case the volts line loss is five per cent. of 220 or 11 volts and as 15 amperes will supply the lamps the watts lost will be 165. Similarly in the other case 30 amperes flowed and 5.5 volts were lost in transmission, making the watt loss 165, the same as with the 220 volt system. The proper size of the wire would, therefore, be as follows:

Resistance of line $= \frac{11}{15} = .733$ ohm and the resistance per foot will be $\frac{733}{200} = .003668$ or exactly four times as great as with the 110-volt system, and therefore requiring a wire only one-fourth as large. To come to actual sizes, the wire for the 220-volt system would be No. 15 B. & S. and would perform the same service as a No. 10 wire in the 110-volt system.

In spite of numerous disadvantages which this system possesses, the great saving of copper that it affords has been a substantial consideration, and several modifications have been made to eliminate some of the more prominent objections while retaining in a marked degree the great merit saving of copper.

Among other methods the device shown in Fig. 2 was tried. This idea is to connect together the portions of the circuit between the lamps by a third wire.

This obviates the necessity of turning two lamps on when only one is desired, and adds a little copper to the system. However, the system must be very nearly balanced or otherwise the lamps on the side where there are few would burn much brighter than the lamps on the side where there are many, and this objection has proven serious in practice. In fact, this method was only a make-shift to avoid the three-wire patents.

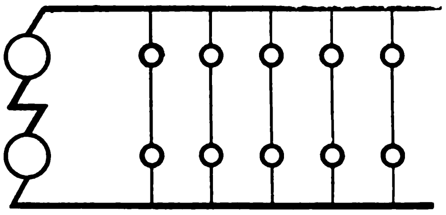


FIG. 1.—220-VOLT SYSTEM.

The three wire system, pure and simple, merely embodies the device of connecting the middle wire of the system just described, to the common terminal of the two dynamos. This obviates every difficulty of operation as far as the lamps are concerned. Unevenness of lamp load merely throws more load on one dynamo than on the other, but in no way affects their operation.

Suppose that a three-wire system existed where all of the lamps on one side are lighted and none on the other. It is obvious that if it were the positive side the current would pass out through the positive wire and return through the middle or neutral wire. None whatever would return through the negative wire, because it is disconnected and the corresponding dynamo

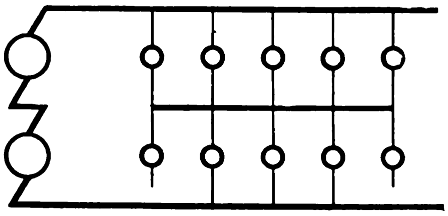


FIG. 2.—MODIFIED 220-VOLT SYSTEM.

will have no load. Now if a single lamp be turned on on this side, a load is thrown on the dynamo and the current for a single lamp will leave the neutral and flow to the place of lower potential through the negative return wire and dynamo. As the lamps are turned on one by one, a proportionate amount of current leaves the neutral to return by the negative wire until at last when the number of lamps on both sides are equal, no current flows therein because the potential difference between its ends is zero.

If lamps on the positive side are now turned off there will be a current in the neutral, but it will be in the reverse direction and will increase in magnitude as the lamps on the positive side continue to be turned off.

If the system is well subdivided—that is, the lamps are everywhere evenly distributed on either side of the neutral—the current flowing in the latter will be very small. In large installations, such as that of the New York or Boston Edison companies, the percentage of current in the neutral wire is but a few per cent. of the current in the outer mains, sometimes flowing in one direction and sometimes in the other.

In spite of the fact that the current that flows in the neutral wire is small, it does not follow that this wire should be small in proportion, for the loss of voltage in it is felt at the lamp terminals, causing inequality between the two sides.

Consider a case where the neutral is the same size as the outer mains. Assume that the lamps are evenly divided and that in each outer main there is five volts drop. The dynamos generate 115 volts each, and the lamps are fed at a voltage of 110. The neutral carries no current. Now, if all the lamps on one side are switched out, the current in the other main is not lessened, and an exactly equal current is now carried by the neutral. Five volts are lost in the outer main and five volts in the neutral. Thus the total loss is ten volts as before, but *one set of lamps* must receive the voltage of one dynamo less ten volts or burn at 105 volts. This is the extreme case and intermediate ones would show a proportionate loss in voltage. Hence a liberal neutral is desirable even though it often involves a large quantity of idle copper. A common size for the neutral is one-half or two-thirds the size of the outer mains in street systems, but even if it were the same size as the latter the total copper would only be three-eighths of that of a 110-volt system of the same extent, the line loss in watts being equal. It is poor practice to attempt to save on the neutral in interior wiring.

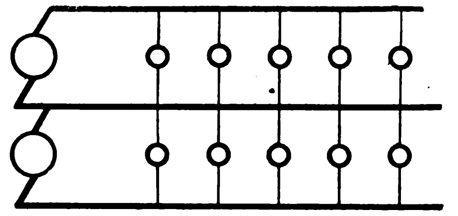


FIG. 3.—THREE-WIRE SYSTEM.

In wiring a building by the three-wire system, it is often desirable to make the neutral double the size of the outer mains. This enables service to be taken from the three-wire system, and by connecting the outer mains together and applying the terminals of a dynamo to one of the mains so connected and the other to the neutral, the system can be operated as a two-wire system.

The line loss in this case will be double the value when the system is operating on the three-wire mains, and must be supplied by the generating dynamos if the lamps are to burn at the same voltage as before. Thus, if a 110-volt system of lamps wired as just indicated were properly lighted by a three-wire supply having a pressure of 115 volts, the dynamos necessary to run the system on the two-wire plan would need a voltage of 120. The extra five volts are used by the neutral wire, which in the case of the three-wire system remained comparatively idle, but when the two-wire system is used carries double the current of one of the outer mains. In many large three-wire plants it is customary to put the neutral wire to earth, and this is important in interior wiring, as extra precaution must be taken. This will be discussed under details of wiring on the three-wire system, which will form the subject of the next article.

FAULTS AND HOW TO FIND THEM.

FAULTS IN REGULATORS.

The new Brush regulator accomplishes all that the old one did, and, in addition, shifts the brushes to their new running position, which was formerly done by hand. The electrical regulation is accomplished in the same way as by the old regulator—namely, by varying a resistance in multiple with the fields—but brush shifting is now effected by mechanical means. A small belt from the main shaft drives a pulley, which in turn, by means of a worm wheel transmission, drives a shaft at right angles to the main shaft at slow speed, but with considerable power. On this latter shaft are mounted two halves of two separate magnetic clutches. The other halves of the clutches are each mounted on a sleeve which is free to turn on the shaft. These sleeves carry bevel gears that mesh with another bevel gear, but on opposite sides. This latter gear is mounted on a shaft that is parallel to the main shaft.

By consulting Fig. 1 it is easy to see that if one of the clutches acts and turns its bevel gear, the shaft last mentioned will be turned in one direction, while if the other clutch acts the motion thereof will be reversed. This shaft carries also on its extremity an arm which swings over contacts and varies the resistance in multiple with the field magnet. A pinion on the same shaft turns a segment fastened to a long arm which is part of the yoke on which the brushes are mounted. Thus, when this shaft is turned, the resistance in parallel with the field is varied and the brushes are moved to a new position. The current is delivered to one or the other of the magnetic clutches, as may be needed, by a wall controller.

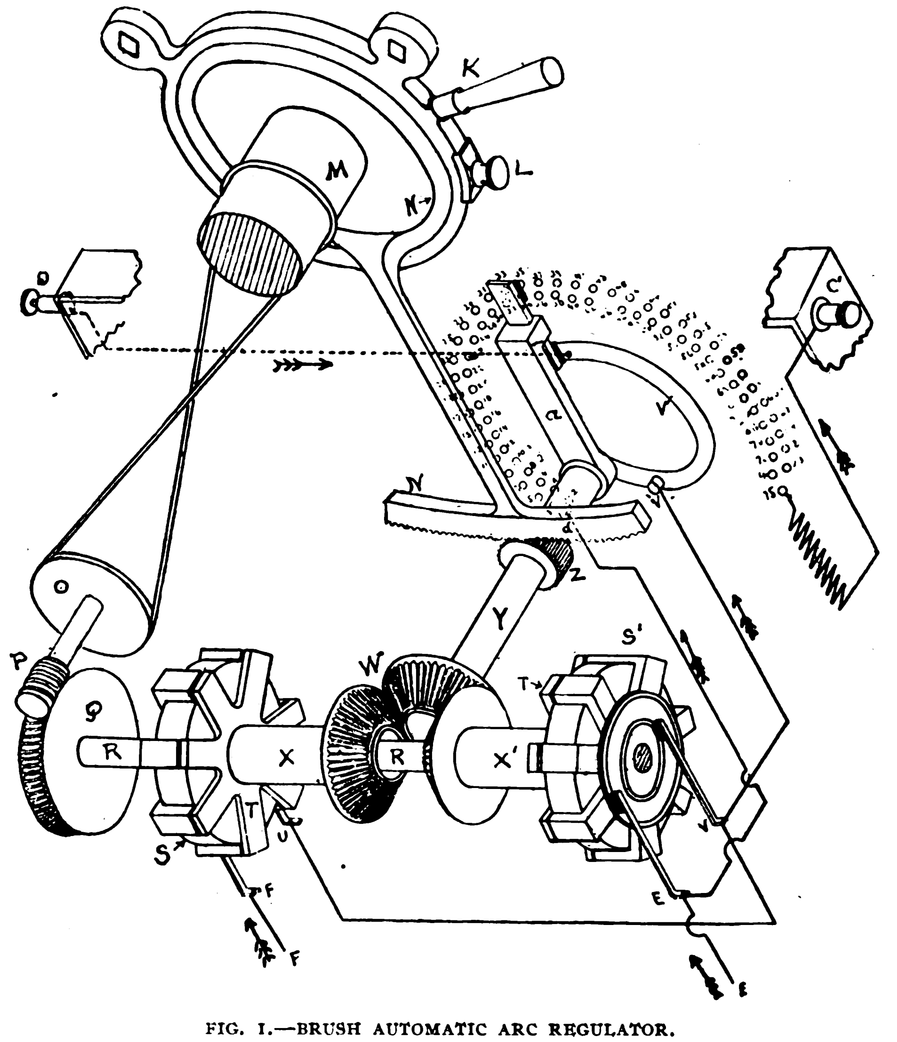


FIG. 1.—BRUSH AUTOMATIC ARC REGULATOR.

The connections of this controller are shown in Fig. 2. In the left of the controller is a resistance, one end of which is connected to the terminal of the field magnet. The other end is grounded on the coils of the magnet system within the box when the small magnet to the left attracts its armature. Two terminals of the clutch coil are connected together and to the terminal of the field magnet, in common with the other end of the resistance already referred to. The lower terminals on the wall controller are connected to the free ends of the clutch coils, and by an examination of the mechanism it will be seen that if the main current which traverses the large wall controller magnets becomes too strong, one of the clutch coils is put in multiple with the wall controller resistance; while if it becomes too weak, the other clutch coil is so connected.

The clutch coils thus depend for their current on the difference of potential at the terminals of the resistence within the wall controller. If this is short-circuited, the machine will cease to regulate, and a small switch shown in the figure is provided to do this. This switch must be closed on starting the dynamo, for when there is no current in the system, the little magnet in the wall controller will open its contact, and were not the switch closed as stated, a complete open circuit accompanied by failure to excite would result.

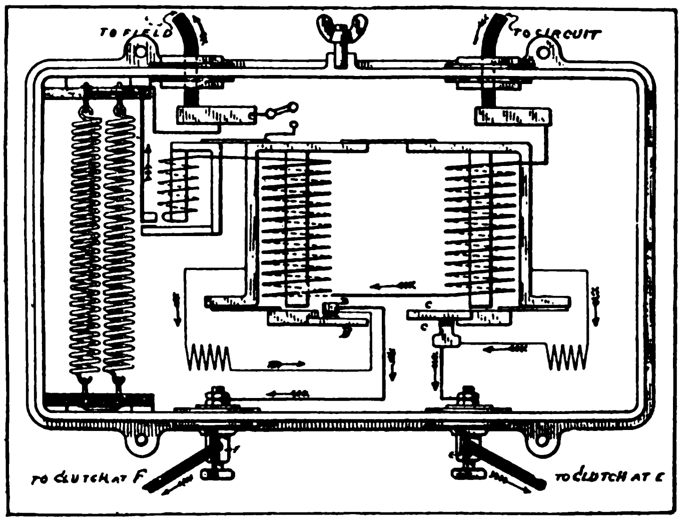


FIG. 2.—BRUSH ARC CONTROLLER.

The connection from *d* to *e* (Fig. 1) places a variable resistance in multiple with the clutch, which acts as the load increases. It has the effect of moving the brushes less as the load comes on for equal increments of load, a movement required by the peculiar reaction effects of the Brush armature. At full load the forward clutch coil is short-circuited, thus preventing any further forward motion, which would result in a serious flash.

The faults that can occur with the Brush regulator are the short-circuiting of the controller magnets and of the clutch coils, and also open-circuiting of the latter. It is to be remembered that the forward clutch coil will test out short-circuited at full load position and that this is as it should be. If the magnet to the left be short-circuited, the clutch coil that moves the brushes backward will fail to act and if the load be thrown off to any extent, flashing will result. If the other controller spool be short-circuited, the forward clutch coil will insist on acting when it should not do so, and severe flashing at the commutator will follow.

If the little magnet fails to act, it will drop its armature and an arc will follow, but the circuit will not be broken. Close the little switch that short-circuits the resistance in the left of the controller and the arc will cease. Regulate through the rest of the run by hand, and when the run has ended search out and remedy the short circuit. The finding of short circuits, or in this case, grounds, has been explained in previous sections. If either clutch coil refuses to operate, look at the wall controller and make sure that the appropriate contact is closed and that the clutch coil is receiving currents. If this proves to be the case, it is probable that the clutch coils are either open or short-circuited. Appropriate investigation and remedy should at once be instigated.

The Wood arc machine has a very simple controller, and any faults that occur therein are very easy to find. It is made in two forms identical in principle, but differing in mechanical detail. On all but one size the arrangement is the same, but for this machine—the 125-lighter—a special form has been designed. The Wood machine regulates by shifting the angular position of its brushes; there are four brushes in all, although the machine has but two poles. These brushes are arranged so that they come in pairs, and the pairs are diametrically opposite one another on the commutator. Part of the regulation is accomplished by moving the brushes as before stated, and the remainder by altering the distance between the pairs of brushes. These pairs are connected together and therefore they short-circuit that part of the armature that is connected between the segments on which the pair rest. The greater the distance between the pairs the less will be the voltage of the machine.

As the distance between the brushes of a pair varies as they together change in position on the commutator, it is clear that they must move at different velocity ratios. This movement is effected by purely mechanical means electrically controlled. A solenoid magnet is arranged to control a set of friction wheels. Two friction wheels are driven by means of pinions from the main shaft in opposite directions. If the core of the magnet drops too far, a third friction wheel will engage with one of the two wheels already mentioned, thus being moved in one direction; and if the magnet core rises too far the other wheel comes into play, imparting a reverse motion. The motion is transmitted to the brushes by a train of gears. The brushes are arranged on two yokes and each yoke is separately driven by the train at different speeds, thus accomplishing the results already indicated.

The 125 light regulator differs only in mechanical arrangement. It uses friction clutches instead of wheels, and has a more powerful train of gears. The only possible faults that can occur aside from incorrect setting of the brushes, is the short-circuiting, open-circuiting or grounding of the operating magnet. The magnet is a part of the main circuit and if it should be cut out by open circuit, all the familiar symptoms of open-circuiting an arc dynamo will occur. Short-circuiting or grounding will weaken the controlling magnet and cause it to regulate for too large a current. A spring provides for the adjustment of the current to which the dynamo regulates, within certain limits, but if the magnet loses strength from any of the three causes just recited, it is probable that this spring cannot be weakened sufficiently to compensate, even if it be taken off completely. If any large adjustment of this spring suddenly proves necessary, it is probable that one of the faults referred to has occurred. Its correction lies, of course, in unwinding and reinsulating the faulty place. Mechanical faults are more tangible and are apparent on inspection, and it is therefore useless to discuss them here.

REPAIR OF STREET RAILWAY APPARATUS.

AUXILIARY WIRING IN RAILWAY CARS.

Although by no means as complicated as the controller wiring, there is opportunity for considerable ingenuity in the wiring that supplies the lamps and heaters of electric railway cars. Even the conductor signals may be operated by the trolley current. For this latter purpose dry batteries have been frequently used, but in a road of 1000 cars the maintenance of 3000 cells is no small item, and is the more objectionable when it can be so easily avoided. This article, therefore, will be devoted to kinks in auxiliary wiring of street railway cars.

The potential at the disposal of the wireman is 500 volts, or more often 550 to 600. Thus if 100-volt lamps are used they must be run in circuits of five in series, and if 50-volt lamps are employed, ten lamps in series are used. This is popularly supposed to limit the number of lamps on a car to five or some multiple thereof, and it is true of *the lamps burning*. However, any number of lamps may be used on the car, and any five or multiple of that number may be lighted. By using this device a number of things may be done.

For instance, it may be desirable to carry an electric headlight on the top of the car in addition to the one on the dasher, for use when the car is traversing long, dark country roads; in the city districts the abundant illumination from the buildings renders this addition unnecessary. Similarly, the device may be used to supply current to a receptacle in which the motorman may plug a portable light to examine the motor when it becomes disabled. In fact, a score of convenient changes could be recited.

Consulting Fig. 1, it will be seen that by manipulating the single-pole, double throw switches, a circuit may be formed through any five lamps of the set of ten there shown. It is obvious that the lamps may be placed anywhere about the car. For instance, the lower five might be the ordinary lighting lamps, and the other five could be auxiliary headlights or emergency portable lights, as might be necessary or desirable. By manipulating the proper switch, it is evident that any lamp within the car may be extinguished and the corresponding auxiliary lighted. Moreover, there could be but one auxiliary as well as five.

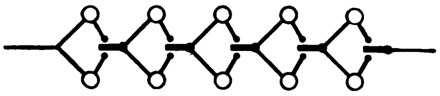


FIG. 1.—SERIES DOUBLE LAMP CIRCUIT.

If there was never a time when the car is in operation that current was not flowing through some device, either a lamp, motor or heater circuit, the installation of an electric bell to work with current from the trolley would be easy, but unfortunately there are times when the car is in active service when absolutely no current is to be drawn from the trolley. If a bell circuit is to be installed, it must contain a large series resistance which is not easy to obtain in ordinary forms. For this purpose incandescent lamps can be used with advantage, and special lamps of high resistance are constructed for such purposes at these. In series with a suitable number of these lamps the electric bell with its button can be connected across the trolley wire and will work as well as if it were on an ordinary battery outfit. It is better to have a magnet wound with fine wire, as this operates with greater satisfaction on small current and high voltage.

Another convenient way is to place a storage battery in series with the lamp circuit; when the lamps are on, it is charging and the bell and buttons may be connected on to the storage battery in the ordinary way. The storage battery will always have charge sufficient to operate the bell and need not be touched from one year's end to another. A very small battery will suffice and the bell need not have a special magnet.

The arrangement of lamps within the car has been more or less of a problem. The sizes of street cars in common use are such that five are too few and ten are too many, there is a similar condition of affairs as exemplified by Dr. Johnson's roast goose, which in his opinion was too much for one and not enough for two. This problem in lighting is usually solved by using ten lights and illuminating the platforms and headlights. A very pretty combination is to have a three-light chandelier in the middle of the car and two two-light chandeliers at the ends. This leaves out three lamps to be placed in other positions on the car. It is customary to place one on each platform and one in the headlight. This is poor practice as regards the front platform. Like an engine cab, it should be perfectly dark to facilitate observation ahead. It is far better to install the extra lamp on the rear platform, or possibly in the headlight.

A combination much used is to have two four-light chandeliers in the car, leaving two extra lights—one for the headlight and one for the rear platform. The distribution of light is not as good in the interior of the car as in the first case. Sometimes four two-light chandeliers are preferred to two four-light ones, and in the writer's opinion this arrangement is the best of all. In small cars where but five lamps are necessary, it is better to have but one extra lamp in the headlight—three in the car and one on the rear platform. Where the cars are double enders and are intended to run in either direction, a switching arrangement should be provided such as that previously described for switching the platform light from the rear to the front platform, or vice versa.

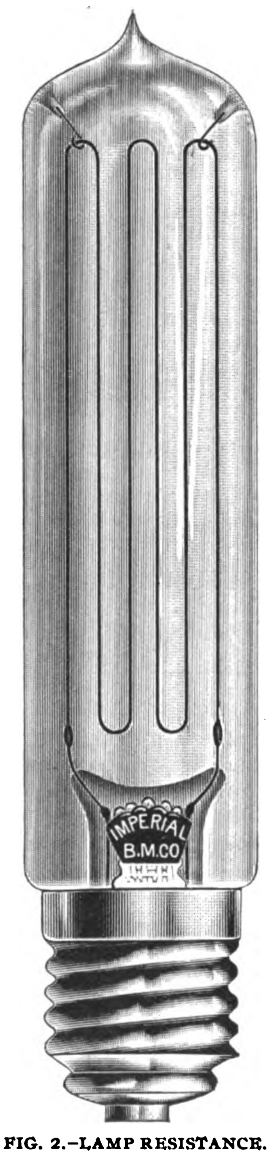


FIG. 2.—LAMP RESISTANCE.

The resistance used in the motor contact or in the diverter, as it is sometimes called frequently gets hot in service—in fact so hot that the hand cannot comfortably bear the warmth. If the motorman is careless it gets red hot. Thus resistance is a large bulky affair and fully equal in volume to a set of car heaters.

Therefore the following device can be utilized with economy and convenience. Wind heater frames with a wire that will safely carry the maximum motor current, and connect the heaters in series; bring down wires to divide the system in three or four parts, according to the system used on the car. The heater switch will be a throw-over switch that will connect these special heaters or the ordinary diverter in circuit for regulating purpose. In winter the former is used and in summer the latter. In crowded city districts the heat afforded by these heaters will be ample, particularly if the motorman is instructed to run on those notches which, with the ordinary diverter in circuit, he is forbidden to use. If the heat proves scanty on long interurban sections, a few regular heaters may be used to supplement, but they should be turned off when the city districts are reached. An ampere at the car is nearly a horse power at the engine, and it should be saved wherever possible.

THE STEAM ENGINE INDICATOR.

BY A. C. LIPPINCOTT.

At the present time the fundamental principles of the steam engine indicator are generally understood and the many advantages to be derived from its use are conceded by every progressive engineer.

The indicator is used simply to take a photograph of the action of steam in the engine cylinder. This it does by recording the exact pressure existing therein at every point of the stroke. From the resultant diagram or "card" we may determine with marvelous precision the power being developed, the adjustment of the valves and their condition. It also informs us if the steam is retarded in its course, either by insufficient steam pipe area or inadequate valve opening.

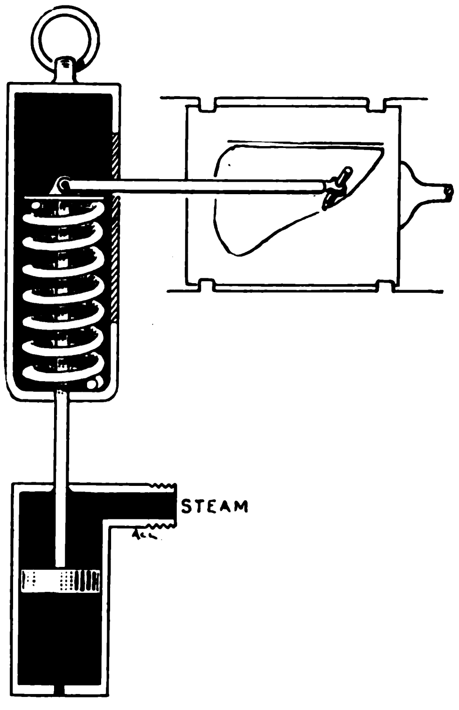


FIG. 1.—MODEL OF INDICATOR.

These points may be more intelligently treated as we discuss different diagrams in future numbers, the purpose of the present article being to consider the principles embodied in the indicator itself.

For a simple example we have only to turn to the familiar spring balance. As we all know, it consists of a spiral spring of known strength, and to this is attached the article to be weighed.

If we consider the scale pan as a piston, and surround it by a cylinder, it may readily be seen that any pressure admitted to the cylinder could be weighed with just as much precision as if it were nails or any other article. For the purpose in hand it is not sufficient to have the pressure *indicated*—we must also record it permanently. To accomplish this object, we may suppose a pencil-carrying arm permanently fixed to the moving end of the spring, the pencil to be in contact with a card moving longitudinally and exactly "in time" with the engine piston. We would then have an instrument practically as shown in Fig. 1, which would be theoretically a perfect indicator.

Practically, many mechanical modifications are demanded to adapt it to engine-room use, and especially to suit the exacting demands of the present age of high pressures and rapid speeds.

In the early days of the steam engine, when ten revolutions per minute was the usual speed, an instrument almost as crude as this was used, and successfully, too.

As the speed increased, the momentum and inertia of the moving parts became important elements to be considered, and in place of the two-inch piston, one of less area was substituted. This in turn demanded a lighter spring. Up to this time, the recording surface was fastened to a board, which was moved forward by means of a cord attached to the piston rod, and was returned by a counterweight.

Evidently this weight must be reduced, and this was effected by the substitution of a cylinder for the sliding board. This cylinder was normally held against a stop by a spring, but almost an entire revolution was permitted.

In this form we find the "McNaught" indicator, and occasionally we meet them in use at the present time, on such work as the beam pumping engine, and giving results considerably better than none at all.

Being confronted by the imperative demand for still lighter moving parts, recourse was had to heavier springs, and consequently less piston movement. This meant smaller diagrams, which rendered defects less prominent and thus to a more or less degree defeated the object in view. However, the reduced piston movement was considered a step in advance and in order to retain this feature, and still provide for a diagram of sufficient size, means were provided to multiply the movement of the piston.

Page after page could be devoted to the many different devices we might enumerate, each with but one object in view, to *correctly* multiply the movement of the piston, with the least possible weight.

Excepting the spring, this is the most important feature of the instrument, and while it would serve no useful purpose were we to attempt to mention each device, yet some of the most ingenious ones may prove interesting, even though they proved failures in practice. Others are of interest for the reason that they have demonstrated sufficient merit to warrant their survival, and this subject will be thoroughly treated in the ensuing number.

◆

Indicator Piping.

In a recent paper, Prof. W. F. M. Goss, of Purdue University, gives the result of some experiments to determine the effect, upon the cards, of long-pipe connections for steam engine indicators. The conclusions arrived at were that if an indicator is to be relied upon to give a true record, its cylinder connections must be direct and short. Any pipe connection is likely to affect the action of the indicator, and a length of three feet or more may be sufficient to render cards valueless except for rough work. The errors thus introduced are more pronounced as the speed of the engine is increased, and proportionately greater for short than for long cut-offs. Within limits, the indicated power of an engine is increased by increasing the length of the indicator piping, while the points of cut-off, release and beginning of compression are all shown later than they should be. With any pipe connection, pressures during the greater part of expansion are higher, and during compression are lower, than actual pressures existing within the cylinder. It follows that conclusions concerning the character of the expansion or compression curves, or concerning changes in the quality of the mixture in the cylinder during expansion or compression, are unreliable when based upon cards obtained from indicators attached to the cylinder through the medium of a pipe, even though the pipe is short.

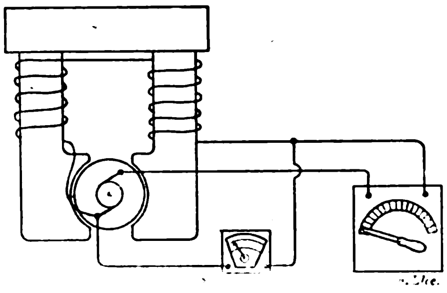
◆

HOW TO COMPOUND A DYNAMO.

BY CECIL P. POOLE.

Under the above heading, a most excellent method of compounding a shunt dynamo was described in the September issue of the American Electrician. The plan suggested is however, open to the objection that it is purely experimental, coming under the head of cut-and-try methods. The writer has found the following to be a satisfactory way of compounding a shunt machine and one which possesses the merit of being particularly simple and convenient of application.

Only two electrical and two mechanical measurements are necessary. With the machine running under full load and giving the proper E. M. F. at the center of distribution, measure the voltage across the terminals of the shunt winding, as shown by the accompanying sketch; then measure the voltage there when the machine is running without any load, but giving the same E. M. F. at the center of distribution; subtract the smaller from the greater voltage and multiply the remainder by 13,500. Call this result *A*.



COMPOUND DYNAMO CONNECTIONS.

Next find, from any wire table, the resistance per 1000 ft. of the field wire, and measure the average length per turn of wire around the core, in inches; multiply this by the resistance per 1000 ft., and multiply the product by the number of amperes which the machine furnishes at full load; call this final product result *B*. Then dividing result *A* by result *B* gives the number of turns required in a series coil to properly compound the machine.

If the field wire is not accessible for measuring its gauge, this data can be obtained from the builder. The average length of each turn of wire is ascertained by measuring with a tape around the outside of a coil and also around the core close to the head of the coil; add these measurements together and divide their sum by 2.

The method is more easily expressed by a simple formula in which the various numerical values are represented by symbols. If V, represents the voltage across the shunt terminals at full load; v, the voltage there at no load; r, the resistance per 1000 ft. of the field wire; l, the average length per turn, in inches; C, the full load current furnished by the machine, then

$13{,}500 \times V - v$ divided by $r \times l \times C =$ total number of turns required in the series winding. Or,

$$\text{series turns} = \frac{13{,}500\,(V-v)}{rlC},$$

which is the total number of turns to be put in the series coil or coils.

The series coils should, if possible, be wound over the shunt coils already on the machine, and if shorter than the latter, they should be located at the pole-piece end rather than next to the yoke. If the dynamo is not too large (750 amperes or under) thin flat copper ribbon from 2 to 4 ins. wide with heavy shellaced muslin wound in between layers, is the most convenient material to use for the series coils.

◆

Underwriters' Rules.—The Underwriters' National Electric Association will hold its annual meeting in December, and in the meantime invites suggestions from those interested as to changes or additions to the present code of insurance rules, that are thought desirable, which suggestions will be considered at the said meeting. By application to C. M. Goddard, 55 Kilby Street, Boston, Mass., blanks for this purpose may be obtained; or a rule which it is thought should be amended may be written out in its amended form, followed by reasons, briefly and succinctly stated, for the proposed change, and forwarded to the above address. A separate sheet should be used for each rule considered. As this furnishes an unique opportunity for bringing to the attention of the body which formulates the code of electrical insurance rules now in general use throughout the United States, grievances concerning any of its present provisions, advantage should be taken by electricians and others of the invitation to send in suggestions.

◆

Rating of Electric Railway Motors.—The General Electric Company will hereafter add to the present rating numbers of its electric railway motors, a letter denoting the combination of winding and gear ratio used in each specific case. The numerals, 800, 1000, etc., will hereafter merely denote the particular form of frame, and not as heretofore, represent the capacity or drawbar pull of the motor. This change is brought about from the fact that various combinations of winding and gearing in the same motor are now frequently required, and thus with the same frame the tractive force varies, being, for example, 800 lbs. in the G. E. 800 type for only one specific combination.

A BIOGRAPHICAL HISTORY OF ELECTRICITY.

With Alessandro Volta (1745-1827) begins the era of modern electricity, for before him electric force had only been dealt with as associated with static phenomena. Exception should perhaps be made with respect to the experiments of Galvani, but as the significance of these was not understood, and they held no promise of disclosing the secret of current electricity, they may well be passed by.

Volta, who came of a noble family, was born at Como, Italy, in 1745, and at the age of 29 became Professor of Physics in the college of his native town. Five years later he was called to occupy the same chair in the faculty of the University of Pavia, and from 1815 to his retirement several years later, was Director of the Philosophical Faculty of the University of Padua.

While at Como, Volta, in 1775, invented the electrophorus and later devised the straw electrometer to replace the pith ball in experiments with static electricity. He was also the inventor of the first absolute electrometer, his instrument containing the principle in germ which more than a half century later was applied in the Thomson absolute electrometer. The condenser at one time in his earlier career occupied his attention, and he produced a plate form as a substitute for the Leyden jars.

Like many of the eighteenth century philosophers, Volta was an accomplished man of the world. Before the great discovery which has rendered his name famous for all time, he was well known throughout Europe, not only on account of his earlier work, but through relations established during several journeys to European intellectual centers, where he met the prominent representatives of the science of the day. One of his earliest correspondents was the celebrated Abbé Nollet, and his great discoveries were communicated to philosopher friends in London for announcement to the world through the medium of the Royal Society.

The estimation in which he was held even before his discovery of the voltaic pile was illustrated when, in 1796, Pavia was pillaged by French troops, Napoleon ordered that the house of Volta should be spared, and officers of the French army took upon themselves the duty of guards in order to more completely assure protection. Later, Napoleon invited the Italian professor to Paris and attended the sitting of the Institut at which Volta explained the principle of the voltaic cell, joining in the discussion which followed. Volta was attracted to the study of electricity by reading the celebrated memoir of Galvani, published in 1791, and giving the first account of the Bolognese professor's discoveries in what he termed "animal electricity." Very soon after, Volta attacked the conclusions of Galvani as to the cause of the phenomena described, and offered instead his contact theory of the origin of electrical force and its manifestation.

Galvani's theory was that there always exists in the bodies of animals of every species an electricity; that a muscle of the body is a Leyden jar, while a nerve plays the part of a simple conductor; and that when a muscle and a nerve are connected metallicly, equilibrium is disturbed and the electricity circulates from the interior of the muscle to the nerve, and from the nerve to the muscle across the "metallic arc."

Volta contended that no electricity specially resides in animals; that the simple contact of two dissimilar metals disengages electricity, and therefore the phenomena described by Galvani could be explained with reference merely to the metals employed in the experiments, for the reason that these metals applied to the parts of the animal containing juices, and therefore possessing conductive properties, could of themselves and of their own property disturb electrical equilibrium and thereby set electricity in motion.

These two views gave rise to a controversy which extended to all of the scientific circles of Europe. The learned of the day divided themselves into two camps one committed to "contact electricity" and the other to "animal electricity"; a society was formed at the University of Bologna to uphold the theory of Galvani and one at the University of Pavia to maintain that of Volta. Though many great leaders of thought took part in the controversy, interest remained centered in the principals, who for five or six years alternated in publishing papers sustaining their respective views, the victory appearing to lie at times with one and at times with the other. A French writer has well said that the memorable scientific struggle between these two great minds will always live in the history of science, not only on account of the greatness of the questions involved, but also because of the courtesy and dignity of tone by which the controversy was characterized.

ALESSANDRO VOLTA.

Volta up to 1799 was handicapped in establishing his theory before the world by the small quantity of electricity, and consequently slight effects, he could obtain by simple contact, and continually sought means whereby he could augment these to such a point as to render the truth evident to the entire world without other ado. Finally, in the year named he was successful, and by the invention of the pile which bears his name, at a single stroke comfounded his adversary for all time, and exalted his name to an altitude where that of Faraday alone keeps it company.

The discovery of Volta was that in multiplying couples formed of disks of copper and zinc soldered together in alternate relation—the couples being separated by damp bodies, such as disks of cloth wetted with a saline or acid solution—and so placed that a zinc disk is always between two copper disks and vice versa, then a tension is produced between the terminal disks of the pile sufficient to produce effects similar to those obtained from the Leyden jar, which until then had been, with its static generator, the only considerable source of electricity. To this invention, whose greatest significance lies in the accompanying discovery of current electricity, we owe the entire development of modern electrical science and industry.

Volta seemed satisfied to rest upon his laurels after this crowning achievement, for though he lived until 1827, his only further contributions to science were a few papers on meteorological subjects. Not being a mathematician or chemist, he was debarred from participating in the development in electrical science which followed his discovery, and he had arrived at too advanced an age when electromagnetism began to receive attention.

In 1792, Fabroni, a Florentine chemist, attributed the effects noticed by Galvan and Volta, not to animal electricity nor to the simple contact of dissimilar metals, but to chemical action. This view received little cosideration for some years, the controversy concerning the two older theories apparently absorbing exclusive attention. The invention of the voltaic pile, however, immediately led to the study of the chemical effects which accompany the production of voltaic currents, and the construction of batteries in which the generation of currents of considerable quantity intensified these effects, soon led to the general acceptance of that theory in one form or other. The contact potential theory of Volta has lost favor, while his theory that current is generated by mere contact was early cast aside.

The modern view of voltaic action, as stated by Dr. Oliver Lodge, is that electromotive force is not due to mere contact, but, in the copper-zinc cell, for example, to the greater affinity of oxygen for zinc than for copper. A piece of isolated zinc is 1.8 volts below the potential of the atmosphere and copper .8 volt. When the two metals are connected, they necessarily become of the same potential and the equalization of potential is effected by the rush of electricity across the junction, whereby the zinc receives a positive charge and the copper a negative charge. In air, the equalization of potential is effected in an instant, while in a liquid the negative charge is continually being carried back from the copper to the zinc, and the positive charge from the zinc to the copper, by chains of atoms, so that the potential is here never equalized.

LESSONS IN PRACTICAL ELECTRICITY

THE PRINCIPLES OF INDUCTANCE.

When dealing with continuous currents the only idea that need be associated with the generation of E. M. F. is the simple one of the cutting of lines of force by a moving conductor. With alternating currents, or currents varying in value, however, the case is different. In the transformer, for instance, an E. M. F. is generated in one winding by the mere proximity of another winding carrying an alternating current.

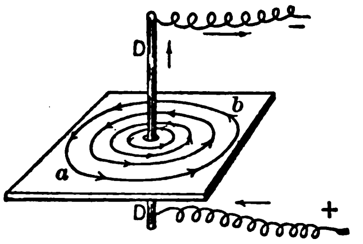


FIG. 1.—LINES OF FORCE DUE TO CURRENT.

In any case, however, the idea of cutting lines of force may be retained. Instead of a moving conductor cutting lines, we can consider that when lines of force are introduced within a closed circuit, they cut through the fixed conductor forming the bounderies of that circuit, cutting in one direction when entering and in another when leaving.

To develop this idea we will begin at first principles, and then take up its various consequences as manifested in the working of magnets, choking coils, inductance of alternating current lines, transformers, etc. It is well to add here that the reader cannot depend upon the ideas formed from the study of continuous currents to aid him in the understanding of variable or alternating currents, unless he adds the further ones connected with the phenomena that result whenever a current changes in strength, the latter being bound up with conceptions not entering in the study of continuous currents. This does not imply that the subject is necessarily a difficult one, but rather one upon which the student should enter with the expectation of encountering a new order of ideas.

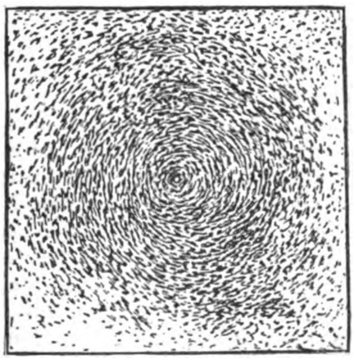


FIG. 2.—IRON FILING PHANTOM OF LINES OF FORCE DUE TO CURRENT.

When a continuous current flows through a conductor, lines of force encircle the conductor, as represented diagrammatically in Fig. 1, and as may be demonstrated (Fig. 2) by means of iron filings. In Fig. 3, is shown the manner in which such lines are disposed in the interior and about the exterior of a coiled conductor. In what follows, account will only be taken of the lines included within a circuit, as in Fig. 4, since they alone produce an effect in that circuit.

If a constant current of 10 amperes flows through a single turn of the coil in Fig. 4, it will produce in its interior 12.56 lines of force. The number of lines of force that any coil will produce when such lines pass through *air* alone, is the product of the ampere-turns by 1.256. Thus, if the current in Fig. 4 were only one ampere, since there is but one turn of conductor the ampere-turns would be unity, and the coil would contain but 1.256 lines. If the coil had an iron core, the number of lines with a given current would be enormously increased for the reason that lines of force pass through iron much more readily than through air. In the case of Fig. 4 and with 10 amperes flowing, the presence of iron might increase the lines to two thousand or more. The matter of the magnetic resistance offered by air and iron for lines of force (or the *reluctance* of magnetic circuits) will be taken up later when the magnetic circuit is considered. The present object of this paragraph is to show that for each value of a constant current flowing in a closed circuit, a definite number of lines of force is embraced within that circuit.

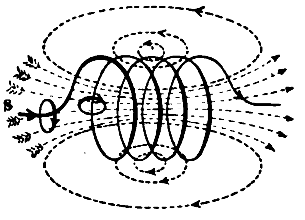


FIG. 3.—LINES OF FORCE OF COIL.

Suppose, now, that the E. M. F. (Fig. 5) causing a constant current to flow in a circuit is withdrawn or short-circuited, so as no longer to affect that circuit, what will be the result? Of course, when current entirely ceases to flow, there will be no lines of force within the circuit, and the lines which the circuit did contain may be considered in passing out to cut through the conductor forming the circuit, this view explaining all of the resulting phenomena. But when lines of force cut any conductor an E. M. F. is developed,* and it therefore follows that after the external source of E. M. F., such as a voltaic cell, is withdrawn, the circuit itself becomes a generator of E. M. F., until all of the lines originally contained have passed out.

The E. M. F. thus generated is called self-inductive E. M. F., or the E. M. F. due to the *self-induction* or the inductance of the circuit. As to its direction with respect to that of the original E. M. F., if a line, *A* (Fig. 5), passes outside of the circuit (from *A* to *A′*) the inductive E. M. F. due to it is in the same direction as the original E.M.F.; if it passes within the circuit (from *A′* to *A*, as when a current is established) it is in the opposite direction.

Taking the case of a current being started in a circuit by the introduction of an E. M. F. (as when a circuit is closed), when the current reaches its normal value, a certain definite number of lines of force will have entered the circuit; in doing so, however, they will, by cutting the conductor in entering, have generated an E. M. F., which inductive E. M. F., as just stated, will be opposite to that of the impressed E. M. F., as it is called, or the battery E. M. F. in Fig. 5.

Before applying the above conception to the alternating current, it will be further developed with respect to the continuous current at the moment when the latter is being established or broken. The reader will understand the connection with the alternating current by reflecting that when a continuous current circuit is made or broken, the current has to increase from its zero to its normal value, or to decrease from its normal value to zero, while an alternating current is one alternately increasing and decreasing in value many times per second.

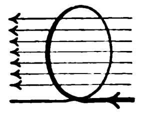


FIG. 4.—LINES OF FORCE OF SINGLE COIL.

Thus far we have not considered the time during which, after an E. M. F. is introduced or withdrawn, the lines of force are passing in or out of a circuit, such as that of Fig. 5. It is evident that this, in the case when the impressed E. M. F. is removed, depends on the number of turns through which the lines due to the original current have to cut, and also upon the resistance of the circuit. For it is evident that the larger the number of coils, the greater the number of conductors to be cut and, therefore, the greater the inductive E. M. F.; and the lower the resistance, the larger the inductive current and, therefore, the larger the number of new lines introduced by it, and replacing part of those passing out.

To resume, and referring to Fig. 5, when the E. M. F., is withdrawn, of course, the flow of current from that source ceases. But as this current ceases, the lines that accompanied it, in order to pass out, have to cut the embracing conductor, and thus generate, as above described, an inductive E. M. F., depending for its value upon the number of turns; this E. M. F. in turn generates a current depending for its value upon the resistance of the circuit; this current then introduces its lines into circuit, thus replacing some of the original lines passing out, which process goes on until the last line of force has disappeared from the

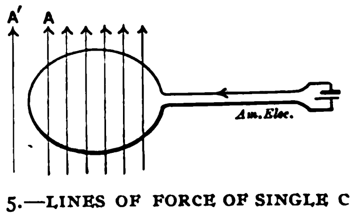


FIG. 5.—LINES OF FORCE OF SINGLE COIL.

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*While this statement is true in general, it may happen that an E. M. F. generated at one point of a conductor may neutralize that generated at another point, as in the case of a loop moving in its own plane and cutting through a uniform magnetic field of force.

circuit. In the case of a make-circuit or increasing E. M. F., the lines due to the current being established pass from without into the circuit, thus creating a current opposing the battery current or current due to the impressed E. M. F., and causing that current to come gradually instead of suddenly to its normal value. In the case of an E. M. F. removed from a circuit, the lines due to the current which had been flowing pass out of the circuit, thus creating a current which flows in the same direction that the battery current did, thus gradually tapering off the original flow. The time required after closing a circuit for a continuous current to attain normal value, or for it to disappear upon removal of the impressed E. M. F., depends, first, upon the resistance in circuit, becoming greater if this resistance is decreased; and, second, upon the number of turns in the coils and the number of lines they embrace, becoming greater if these are increased. Finally, the number of lines in circuit, as shown in the third paragraph, depends upon the current flowing in a coil, the turns and whether the coil surrounds air or a magnetic material, such as iron.

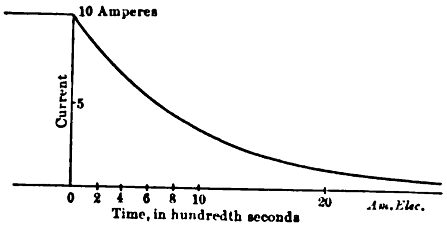


FIG. 6.—CURVE SHOWING DYING AWAY OF CURRENT.

It should be added that were it not for secondary actions entering, a current, when a circuit is closed, would never attain a normal value, or would never die out when the impressed E. M. F. were removed. This will be seen to follow from the fact, that for each certain number of lines removed or introduced into the circuit, a certain number of inductive lines are generated. The curve in Fig. 6 shows the manner in which the current dies away when the impressed E. M. F. is removed, and the curve in Fig. 7 illustrates the manner of increase. The resistance of the circuit in each case is one-tenth ohm, the self-inductance (or coefficient of self-induction) being 10 millihenrys. Self-inductance as expressed in henrys is explained below.

Another point to be observed is that the inductive lines can never equal in number the lines which create them on account of the resistance of the circuit; they will approach more nearly to this number, as before explained, as the self-inductance increases or as the resistance decreases.

We have seen that the inductive E. M. F. depends upon the number of turns in a circuit, and upon whether the lines of force pass through air, or through magnetic material, or partly through air and partly through magnetic material. An alternating transmission line, for instance, corresponds to a single turn, and its lines of force are in air; an electromagnet is an example of a large number of turns whose lines of force pass, when the armature is in contact, entirely through iron; the alternating current transformer is another example of an all-iron magnetic circuit, while the field of a dynamo represents a part air and part iron magnetic circuit.

As in a given inductive circuit the number of turns and the magnetic conditions do not vary, a given increase or decrease of lines will always create the same inductive effect; we may therefore express the inductive value of such turns and magnetic condition in terms of inductive effect or inductive E. M. F. Suppose, for instance, that we have an inductive circuit, such as that of an electromagnet, having 1000 turns, and with a magnetic circuit of such shape, dimensions and magnetic conductivity that an increase of one ampere of current in the coil will add 100,000 lines to the magnetic circuit. Then, if the current is uniformly decreased in strength by one ampere per second, 100,000 lines will pass out each second; these lines cutting the 1000 coils will be equivalent to 100,000,000 lines cutting a single wire and will thus generate that number of absolute units of inductive E. M. F. But a volt, the practical unit of E. M. F., contains 100,000,000 absolute units of E. M. F., and therefore the above operation will produce an inductive E. M. F. of one volt to act against the change of E. M. F. and "choke" or oppose the change of current. A circuit in which a change of one ampere per second produces one volt of inductive E. M. F. is said to have a *self-inductance* or *coefficient of self-induction* of one *henry*. If in the above case, the inductive E. M. F. with a current changing one ampere per second has been 10 volts, the self-inductance of the circuit would be 10 henrys.

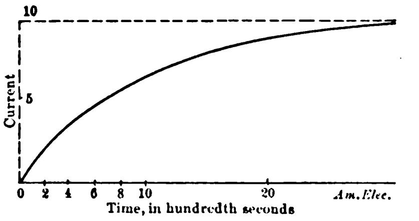


FIG. 7.—CURVE SHOWING ESTABLISHMENT OF CURRENT.

As a practical application of the above principles, let us take the case of a magnet having 5000 turns and a resistance of 40 ohms; we will further suppose that the magnet armature will release one-tenth second after the impressed E. M. F. has been removed by being short-circuited out of circuit.

Let us first see what effect will follow if the number of turns is doubled, but the strength of the magnet kept the same—that is, the current halved and the ampere-turns kept the same.

Since the ampere-turns remain constant, the number of lines to pass out is the same in both cases; as these lines, however, will have to cut twice as many turns in the second case, the inductive E. M. F. will therefore be doubled. If, now, there were no other resistance in circuit than that of the magnet turns, the circuit resistance would also have been doubled when the turns were doubled; the inductive current at any moment, being the quotient of the inductive E. M. F. by the resistance in circuit, would therefore remain the same as before, and the magnet would be neither quicker nor slower in working.

Let us next see if, instead of no resistance in the external circuit, there had been 40 ohms. As the magnet is to retain the same strength, the current and therefore the number of ampere-turns would be the same, and consequently the inductive E. M. F. would be the same. But the resistance of the circuit is now 40 + 40 = 80 ohms, instead of 40, as in the first case, and only half the inductive current would flow, and the magnet would be released in half of the time, or in $\frac{1}{20}$ second, instead of $\frac{1}{10}$ second.

If now, in this latter case, the number of turns are doubled and the inductive E. M. F. thereby increased (the strength of the magnet remaining the same), the new resistance—that is, the sum of the external resistance and that of the new magnet resistance—is 120 ohms. While thus the inductive E. M. F. has been doubled, the resistance in circuit has only been increased from 80 to 120 ohms; consequently a larger amount will flow at any instant and the magnet will not release until $\frac{1}{15}$ second instead of, when the turns were one-half so great, in $\frac{1}{20}$ second. Doubling the turns in this case thus makes the magnet work slower.

The statement is usually made that adding turns to a magnet makes it slower in working. The principles just developed enable us, however, to see that if the resistance of the external circuit is very small compared with that of the magnet, increasing the number of turns does not appreciably affect its working, provided the strength of the magnet is kept constant. We also see that a magnet may be made quicker working by merely introducing resistance into the external circuit, the E. M. F. in circuit being at the same time increased in order to keep the current and strength of magnet the same.

In any case, however, it is to be understood that any such additional resistance must not possess appreciable self-inductance, as otherwise it would itself introduce inductive effects in circuit and thereby render the above conclusions inapplicable. A non-inductive resistance is one whose circuit contains such few lines of force that their cutting when an increasing or decreasing current passes, produces an inductive E. M. F. which is negligible. The filament of an incandescent lamp is an example, as the number of lines of force in its loop is extremely small in comparison with its resistance, which may be from 50 to 450 ohms. A wire looped back and forth with the several lengths close together is another example; in this case not only is the space for lines of force small between wires, but part of the lines of even-numbered lengths and of odd-numbered lengths, tend to respectively neutralize each other. Similarly, a coil made of a single loop with the insulation of its two parts touching will be non-inductive, for the reason that the effect of the current passing in one part will be neutralized by that passing in another.

In a succeeding article further application or the above principles to electromagnets and dynamo fields will be made.

Letters from Practical Men

Upward Lightning Discharge.

During the summer I had the opportunity of examining two oak trees which had just been struck by lightning. In both cases the path of the discharge, as indicated by the rending of the bark and the splitting of the wood next to the bark, was single along the trunk, but bifurcated when it came to the main branches. The fact of this bifurcation of the rent appears to me to indicate that the discharge passed from the roots upward, not from the top branches downward.

ALEXANDER MACFARLANE.

Practical Method for Compounding a Shunt Dynamo.

The following method for compounding a shunt dynamo so as to give a constant potential at the brushes for all loads, is very simple and accurate.

Wind over the shunt fields a known number, S, of turns of rather heavy wire and connect, in series with an ammeter and a variable resistance, to the terminals of an outside source (not the dynamo under test). The machine is started up (with the circuit of added turns open) and the field rheostat adjusted to give normal potential at no load.

Full load is added to machine, which causes the voltage at the brushes to drop. Sufficient current is sent through the extra turns in the right direction to build the voltage up to normal, and the values of the current in the extra turns, C, and that in the mains, C', noted.

Then the number of series turns to be added are

$$\frac{S\,C}{C'}$$

The above applies to dynamos of the single horse shoe or salient type. For a consequent pole type machine (e. g. the Manchester type), wind on each limb an equal number of turns and connect so that these extra turns assist the shunt turns. Then S equals total number of turns added and the calculation is the same as above.

A. F. MCKISSICK.

A Cheap Oven.

Nearly all the roads at the present time are doing more or less armature and field spool repairing. A great many more roads would do so, but are prevented on account of the expense of the appliances necessary to do the work in a proper manner. In fitting up to do this work, in order to thoroughly dry the shellac or whatever insulating material is used, an oven is quite essential, and I shall endeavor to describe a cheap oven I recently had constructed and which gives as good results as an oven costing many times the amount expended on this one.

A wooden box, three feet square by two feet deep, was procured. This was a box in which a Westinghouse No. 12 motor was received and consequently cost nothing. The box was lined with a layer of asbestos and inside of that a layer of roofing tin, and placed in a position so that armatures could be raised and lowered by a traveling crane.

To heat the oven, electric car heaters were tried at first, but it was found that too much resistance had to be placed in circuit to control the heat, thereby causing a great waste of energy. After considerable experimenting it was found that ten 16-CP, 100-volt incandescent lamps would raise the temperature in the oven to 220 degs. F., which is about the usual temperature used for this purpose.

This is a very economical and efficient arrangement, as no energy is expended outside of the oven, and a very small current is used, about one ampere being all that is required.

FRANCIS G. DANIELL.

Acid Joints. Electrolytic Corrosion.

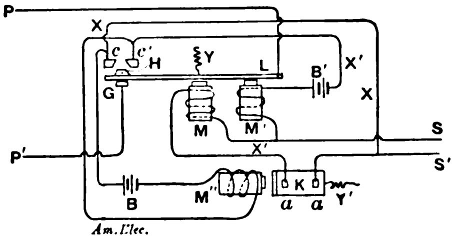
In looking over your department of "Letters from Practical Men," it occurred to me that an account of several instances of electrical trouble in my experience may be of interest to electricians. Some years ago I had the unenviable honor of acting as expert for a line of steamers whose electrical plants were amongst the first installed aboard vessels. One evening I was sent for in haste, and when I arrived aboard was told that the boat was ready to get under way, but that the lamps would not light. There was no voltmeter, and the pilot lamp on the dynamo which took its place I found to light all right when the engine was started. Disconnecting the pilot lamp with which to test across, it was found to light from the brushes to the lugs of the dynamo, but, very curiously, not when connected across the switchboard upright leads soldered into the latter. Upon close examination, one of these leads (about No. 00 in size), was found to be loose in the lug, which was also very hot; when the lead was pulled out it was found that contact had been prevented by a layer of fine white powder. A screw lug was substituted and fastened to the dynamo frame by using the old lug as a "washer," one of its bolts—which fortunately were quite long—passing through a bolt hole of the new lug. This is an example of a very serious defect of acid soldered joints.

On another occasion when the writer was sent for, the lamps in one end of the saloon of a sister boat refused to come above a dull red, though other lamps in it burned brightly from the dynamo end of the same main. The fuses and contacts were found all right, and as to take the capping off the moulding behind the saloon berths would have delayed the boat too long, it was concluded to let things go for that trip. However, when picking up a hat from one of the berths, a green streak was seen below the moulding, which reawakened interest. Upon tearing the capping off, the moulding burst into flame about the green place, and was extinguished only after some little difficulty. Upon examination it was found that the main (about No. 4 wire) had been much corroded; in fact, the ends of the wire taken out actually had a point as fine as that of a needle. A leak in the deck above had kept the moulding damp at this place, which had produced electrolysis of the positive lead. The heat from the hot corroded section of the wire, and also possibly from the leakage of current through the metallized wood from one lead to another, had heated the moulding to such a degree, that when exposed to the atmosphere it instantly burst into flame. The trouble was temporarily repaired by bending up the corroded ends and soldering on a piece of wire connecting them.

S. L. RAND.

Transformer Automatic Cut-out.

Upon seeing in the report of the proceedings of one of the electrical associations some time ago, that there was a demand for a transformer automatic cut-out, I spent a few hours in devising one, the result of which is outlined below. Of course, it is very doubtful whether there would be any actual saving with the device described, for, aside from considerations as to difficulty of insulation and complexity of parts, one of the batteries used would have to supply current as long as the circuits were open.



Am. Elec.

Referring to the accompanying illustration, G is one terminal of the primary circuit; PP' is the primary circuit and SS' the secondary circuit; B, B' are batteries; M, M' M'' are magnets, M being fed from the secondary circuit and M' and M'' by the batteries; L is a lever forming part of primary circuit; H is a metal lug on the lever and fitting between $c\,c'$, which are contacts that are short circuited by the moving up of the lever, L; $a\,a'$ are contacts forming part of the secondary circuit; $Y\,Y'$ are springs which contract and draw back the lever, L, and the switch, K, upon their being released by their magnets; K is a sliding switch.

The operation is as follows: When current is being used in the primary circuit, the lever, L, rests on the block, G, and the switch, K, remains in contact with $a\,a'$; thus both secondary and primary are closed. When there is no current in the secondary. the magnet, M, releases its hold on the armature attached to the lever, L, which is then drawn up by the spring, Y; as the lever goes up, it short circuits $c\,c'$, by means of the lug, H, thus completing a path through the battery, B, and the magnet M''; M'' then attracts its armature attached to the switch blade, K, thus opening the secondary. We now have both primary and secondary open.

Suppose a lamp is turned on. The circuit through the wires, XX', containing battery, B', and magnet M', is completed; M' acts on the lever, L, drawing it down to its former position against G, thus again closing the primary circuit. The closing of the primary opens the circuit which holds ihe switch, K, open; therefore, the magnet, $M,''$ being no longer energized, releases its hold on the switch, K, again completing the secondary circuit. So that we have an automatic device by means of which we may cause the primary of a transformer to reach on the secondary, and vica versa.

W. SONNEBERG.

ELECTRICAL CATECHISM

67. How may the voltage of a shunt machine be regulated?

This is usually done by adjusting the rheostat, which is a variable resistance connected into the circuit of the shunt field magnet coil as shown in Fig. 1. As resistance is cut out of the rheostat, more current pasess through the field magnet coil and increases the amount of magnetism, which correspondingly increases the total voltage induced in the armature. Another method which can be used to a limited extent with most incandescent dynamos is to move the brushes slightly forward or backward, so long as they do not spark.

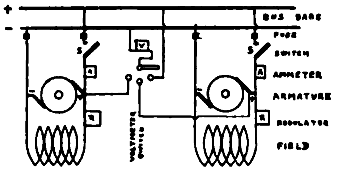


FIG. 1.

68. How can one machine be thrown out of circuit when the load drops off so that the load can be handled by the remaining machine?

Move the rheostats and brushes of both machines so as to shift the load from one machine to the other without disturbing the voltage on the mains, as explained in No. 66, AMERICAN ELECTRICIAN, October, 1896, page 216. When all the current is off from one machine, its switch may be opened and the machine may then be stopped.

69. How can both machines be shut down at once if the load does not go off so that one machine can handle it?

If both dynamos are driven by the same engine, the simplest way is to shut off steam slowly and let both dynamos and engine die together. If this is not practicable, move both rheostats around gradually to the position of lowest voltage, watching both ammeters and being careful that the voltage drops equally on both, and then open both main switches at the same time.

70. What will happen if one attempts to couple two dynamos, one of which has become reversed?

This will make a bad short-circuit and will melt the fuses on both machines, besides burning the brushes and commutators badly. It is also liable to strip the armature wires out of place and to break the belts or throw them off.

71. How can one tell whether a dynamo is reversed or not?

The voltmeter will usually show it. If the voltmeter is not one of the variety with a permanent magnet, it will not indicate polarity. If the voltmeter is connected as shown in Fig. 1, it would indicate double voltage when connected to the dynamo which is reversed.

72. How can one correct a dynamo that is reversed?

Lift the brushes and then close the main switch, so that current from the mains will flow through the magnet coil and magnetize the field properly. Then move the rheostat to the position of lowest voltage so as to reduce the current through the fields; open the switch slowly; then place the brushes in position and let the machine build up.

73. Why should the switch be opened slowly after magnetizing a dynamo?

This is to avoid danger to the insulation of the field coils on account of the high voltage induced in them. When the current ceases to flow through the field coils, the machine begins to lose its magnetism, and the number of magnetic lines of force through the field coils diminishes correspondingly. This induces an electromotive force in the coils in such a direction as to tend to keep up the magnetizing current. The induced electromotive force is proportional to the number of turns of wire in the coils, and also to the rapidity with which the magnetic field changes strength. It follows then that when the current through a shunt field coil of many turns of wire is cut off suddenly, an electromotive force is caused that may be several times higher than the ordinary working voltage, and so may cause a spark to jump through the insulation, and thus make connection between the coil and the frame of the machine, or short-circuit part of the coil. By putting in all the resistance of the rheostat and then opening the switch slowly, the current dies out gradually and the induced electromotive force becomes comparatively harmless.

74. Why does the voltage of a shunt dynamo fall off after it has been working for some time?

This is because the machine gradually becomes warm by use. The resistance of the wire in the field and armature windings increases about four-tenths of one per cent. for each degree Centigrade rise of temperature, or one per cent. for every five degrees of the Fahrenheit scale. Therefore, as the dynamo warms up by working, the resistance of the shunt field coils increases and less current passes through them. This weakens the magnetic field and so lowers the voltage of the dynamo. In order to keep up the voltage of the dynamo it is therefore necessary to cut out some resistance from the rheostat in order to balance the increasing resistance of the field coil.

75. Why does a dynamo get warm by working?

It is impossible to entirely avoid friction at the bearings and between the brushes and commutator. There is also some unavoidable loss by what is known as "hysteresis" or magnetic friction, as the magnetization of the armature is reversed twice for each revolution. A further source of loss comes from the fact that the wire used in the dynamo has more or less resistance which opposes the current somewhat as friction opposes motion. The work done in sending current through resistance, the work in overcoming the friction of the bearings and brushes, and that in overcoming hysteresis and eddy current losses in the armature, all this is changed into heat which raises the temperature of the machine.

76. Why does the voltage of a shunt machine drop off when the load is increased?

This comes from several causes. There is liable to be more or less slipping of the belt as the load increases, thus reducing the speed of rotation of the armature and consequently lowering the voltage. There is also more or less resistance in the machine, part of it being in the wire and therefore unavoidable and part being due to imperfect contact between the brushes and commutator and at other joints in the circuit. Even if the total voltage induced in the armature were not affected by change of load, the resistance in the circuit causes a drop of voltage equal to the product of current by resistance, or the product of amperes and ohms. The voltage between the terminals of the shunt circuit therefore becomes less than the total voltage in the armature, and consequently less current goes through the shunt field coils. This weakens the magnetizing force and in turn lessens the total voltage. Again, the current in the armature coils has a magnetizing effect that weakens and distorts the magnetization from the field coils. This armature reaction is proportional to the armature current and helps lower the voltage as the load increases.

77. How can the voltage of a shunt dynamo be kept up as the load increases?

It is customary to have an adjustable resistance (called a rheostat) in series with the shunt field coils as indicated in Fig. 2. Resistance may then be cut out by moving the rheostat handle as desired. The voltage may also be kept constant automatically by compounding the dynamo.

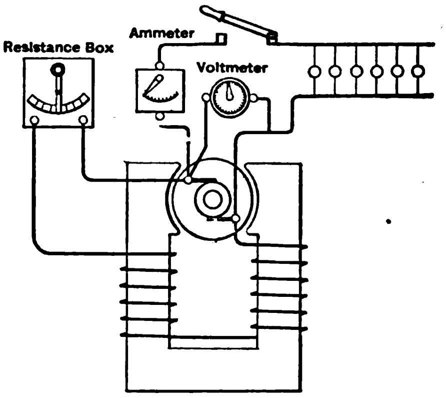


FIG. 2.

78. What is a compound-wound dynamo?

A compound-wound dynamo has two sets of field coils. As indicated in Fig. 3, the shunt coil consists of a large number of turns of comparatively fine wire and is connected to the armature terminals or to the machine terminals, so as to form a shunt to the external circuit. The shunt coil carries a small fraction of the total current and usually furnishes the larger part of the magnetizing force. A compound dynamo has also a series coil of comparatively few turns of large wire which is connected between the armature and the external circuit. The current through the series coil is practically the same as that in the armature and in the external circuit. The magnetizing effect of the series coil is in the same direction as that of the shunt coil and strengthens the magnetization as the load increases. The series coil may be adjusted so as to keep the voltage of the machine constant, or it may raise the voltage as the load increases. In the latter case the machine is said to be "overcompounded."

QUERIES AND ANSWERS

How long does it take a 2-phased induction motor to come up to speed, and will it build up with a good load on? J. C.

Any induction motor with full load gets up to speed in practically the same time as a continuous current motor.

What size and length of wire is best for the primary of small induction coils? C. M.

The query is entirely too general to admit of a definite answer. Two layers of No. 16 or 18 wire may be used with small and medium small size coils to be used with a battery.

1°. How many cells, and of what kind, are required for the spark coil described in this department in the September issue? 2°. What is the object in using a wire as large as No. 12 or No. 14 in spark coils?

1°. Three cells of low resistance, sal-ammoniac type, or five cells of ordinary Leclanché. 2°. The object of the heavy wire is to obtain a "fat" spark.

Would the coil described in Tesla's book on experiments with high potential and high frequency do without any modification for Röntgen ray work? A. S. W.

The Tesla coil referred to can be used for Röntgen ray work, but it must be excited with currents of high frequency from a special transformer. See page 130, August number.

May the resistance in a motor circuit be placed at any point of the circuit without producing different effects? A. L. C.

Yes. In any electrical circuit the position of a resistance introduced is absolutely immaterial. In a motor circuit the effect is the same whether the resistance is connected to the positive or negative pole or located half a mile distant from the motor.

Kindly give a formula for calculating the length and diameter of carbon incandescent lamp filaments made from cellulose. W. E. S.

The dimensions of lamp filaments are not calculated, but experimentally determined. Mathematical formulas could be deduced for this purpose, but would be practically valueless, owing to the indefinite nature of the emissivity and resistivity factors entering.

1°. Can No. 34 wire be used instead of No. 36 in the coil described in the May number? 2.° What would be the size of the primary coil for the above?

1°. Yes, provided the same number of turns are used. It will be well to increase the space between the primary and secondary, filling in with paraffine; one-half inch will not be too much. The advisability of this large space has been demonstrated since the article in the May issue was written. 2°. Two layers of No. 14 wire will answer for a battery primary.

Please give the design and construction of a 20-KW, 110-volt, four-pole generator. H. E. J.

The limitations of our space will not permit answers to be given to questions of this character. Hawkins and Wallis' "The Dynamo" ($3) gives information on the design and construction of dynamos; we would, however, advise the purchase of the necessary drawings from a designing electrical engineer, as the cost of construction of a machine of this size is too large to justify dependence on an amateur design.

What is the difference between the sparking caused by a short circuit in an armature and that caused by an open circuit? F. G. F.

A short circuit within the armature winding will cause no sparking unless a large number of neighboring coils are short-circuited, when the brushes will spark continuously, no matter what their adjustment. An open circuit in an armature winding causes a vicious flash which appears at each brush in turn as the commutator segments belonging to the open coil passes under the brush; the segments will become blackened in a short while.

1°. What size wire, and how many pounds would be necessary, for the primary and secondary of a five inch induction coil? 2°. How many batteries would be necessary to run it? 3°. What is the best insulation for use between the primary and secondary coils? How would a hard rubber tube that would fit over the primary coil make the insulation? J. J. E.

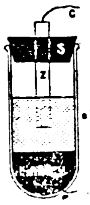
1°. Use No. 36 wire for the secondary; if the coil is well insulated, six pounds will be sufficient. Two layers of No. 14 wire will be sufficient for the primary. 2°. A half dozen large cells of constant current or plunge type will be necessary for good results. 3° A hard rubber tube would be very good, but it should be supplemented by at least ¼ in. of paraffine.

Please give a simple definition of "inductance." R. M. M.

The inductance of a circuit is the measure of the back E. M. F. produced in that circuit by the passage of a variable current, such as an alternating current. The inductance of a circuit is unity or one henry if, while a current passing through it varies in strength at the rate of one ampere in one second, a back E. M. F. of one volt is produced. Any variation of current produces a counter E. M. F., and this is greater or less according to the property of that circuit; that is, in a pole line, the distance apart of the two wires; in a coil, the number of turns and, if iron is present, the amount of iron and its disposition.

1°. How is a Clark standard cell made? 2°. Is it necessary that any copper be exposed to the solution in the Edison-Laclanché cell? F. L. W.

1°. In the bottom of a broad short test tube, is pure mercury, *M*; a platinum wire, *P*, sealed in the bottom of the tube and entering the mercury, acts as one electrode. Over the mercury is a layer of a thick paste, *B*, made by mixing mercurous sulphate with a saturated solution of zinc sulphate. Into the paste dips a rod of pure distilled zinc, *Z*, which forms the other electrode. The tube is sealed with paraffine wax or india-rubber. It is highly essential that all of the constituents of the cell be absolutely pure. To make a reliable Clark cell requires expert knowledge. 2°. No; the negative element (positive electrode) is black oxide of copper, upon which and the zinc the action of the cell depends.



What causes opposite bars on a commutator to blacken up, there being no short circuit in the armature, or the magneto, at least, does not show one in testing it? A. B.

It is impossible to give a conclusive answer unless the type of winding is known. It is probably due to some local defect in the armature. The wires leading to the bars in question may be in poor contact therewith. It may be that the bars in question are high or low bars. If a bipolar machine, the fact that opposite bars are subjected to blackening is probably a coincidence; with a multipolar wave winding having but two brushes, the coils are connected to opposite segments and if the coil is defective in any way any segments to which it is connected might readily be blackened.

Why in calculating the E. M. F. of a bipolar dynamo are the lines of force counted twice? P. L. F.

The E. M. F. is the product of the number of lines in the magnetic circuit (or in a single gap), the number of conductors on the armature, the number of revolutions per second and a constant. The magnetic circuit is cut twice in each revolution, since in one revolution the conductors pass through both gaps; as, however, the commutator divides the armature conductors into two series in parallel, the E. M. F. is similarly divided, and only the lines in *one* gap, or the total flux of the magnetic circuit, enter into the formula. In a rational form, the formula would contain twice the flux and half the conductors, but in multiplying, the 2 and ½ disappear since their product is unity. The manner in which the commutator divides the conductors into two series in parallel is shown in *Lessons* in October issue.

1°. How can I make a small transformer for a 100-volt circuit of a capacity of 5 or 6 amperes and 10 or 12 volts? 2°. How can a storage battery be charged from a 110-volt dynamo or from an exciter. F. W.

1°. Make a ring of ½ in. section and about 4 ins. diameter, of soft iron wire of small diameter. The windings will have to be determined experimentally. For the primary use No. 20 or 22 copper wire, having a sufficient number of turns that when connected to the 100-volt circuit the leads will only be moderately increased in temperature. Then wind the secondary with any convenient size of wire. The number of turns of the secondary will depend upon the voltage required and may be found by trial; or count the number of primary turns and put on less secondary turns in the proportion that the secondary voltage is to bear to the primary voltage—in this case about one-eighth. The size of the secondary wire will depend upon the amount of the secondary current, and in the above case may be No. 18 or 20 wire. Having in the above manner determined the data of the transformer, a neater type may be made by coiling the primary and secondary in 4-in. coils, placing one on the other and wrapping both with the soft iron wire. 2°. Put sufficient resistance in series with the battery to bring down the current to the charging rate of the battery. A single cell can be practically considered as a short circuit on a 110-volt circuit, and must have resistance inserted in series to bring down the current. The resistance may be a number of 110-volt lamps in parallel; if the charging rate is 10 amperes, 20 lamps will be required. A resistance may be made from iron or German silver wire, or a cast-off rheostat may be used, some of the rheostat wires being put in parallel if necessary. In the case of an exciter, connect the cell in series with it and the alternator field; the introduction of a couple of cells will have no appreciable effect on the exciter.

NEW APPARATUS AND APPLIANCES.

ELECTRIC DESK LAMP.

The accompanying illustrations show the Kinsman desk and portable lamps, the latter being ornamented with dark green enamel and gold stripings, all mountings being of brass. The portable type is designed to meet the demand for a desk light where a highly finished fixture is not desired. It is furnished without socket, but is provided with an adjustable holder adapted for any standard socket.

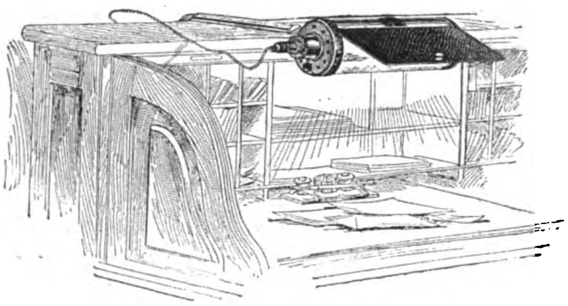


FIG. 1.—DESK LAMP.

The clamp which holds the desk fixture rigidly in place is made adjustable to suit any standard desk without marring it. The enamel fixture contains all the well known features of the nickel plated and polished brass fixture, such as the telescoping tube, the adjustable eye shade, and a revolving glass cylinder with both ground and clear glass surface, which is so made that any standard lamp up to 32 CP in size may be used.

The above described desk and portable fixtures are made by McLeod, Ward & Company, 26 Thames Street, New York.

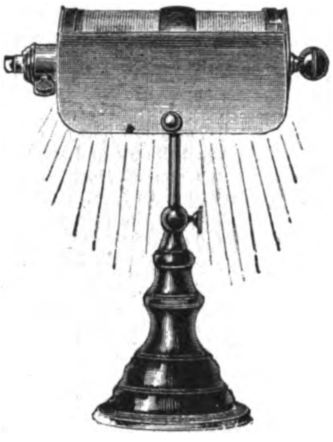


FIG. 2.—PORTABLE LAMP.

AN ELECTRIC RAILWAY STORAGE BATTERY AUXILIARY.

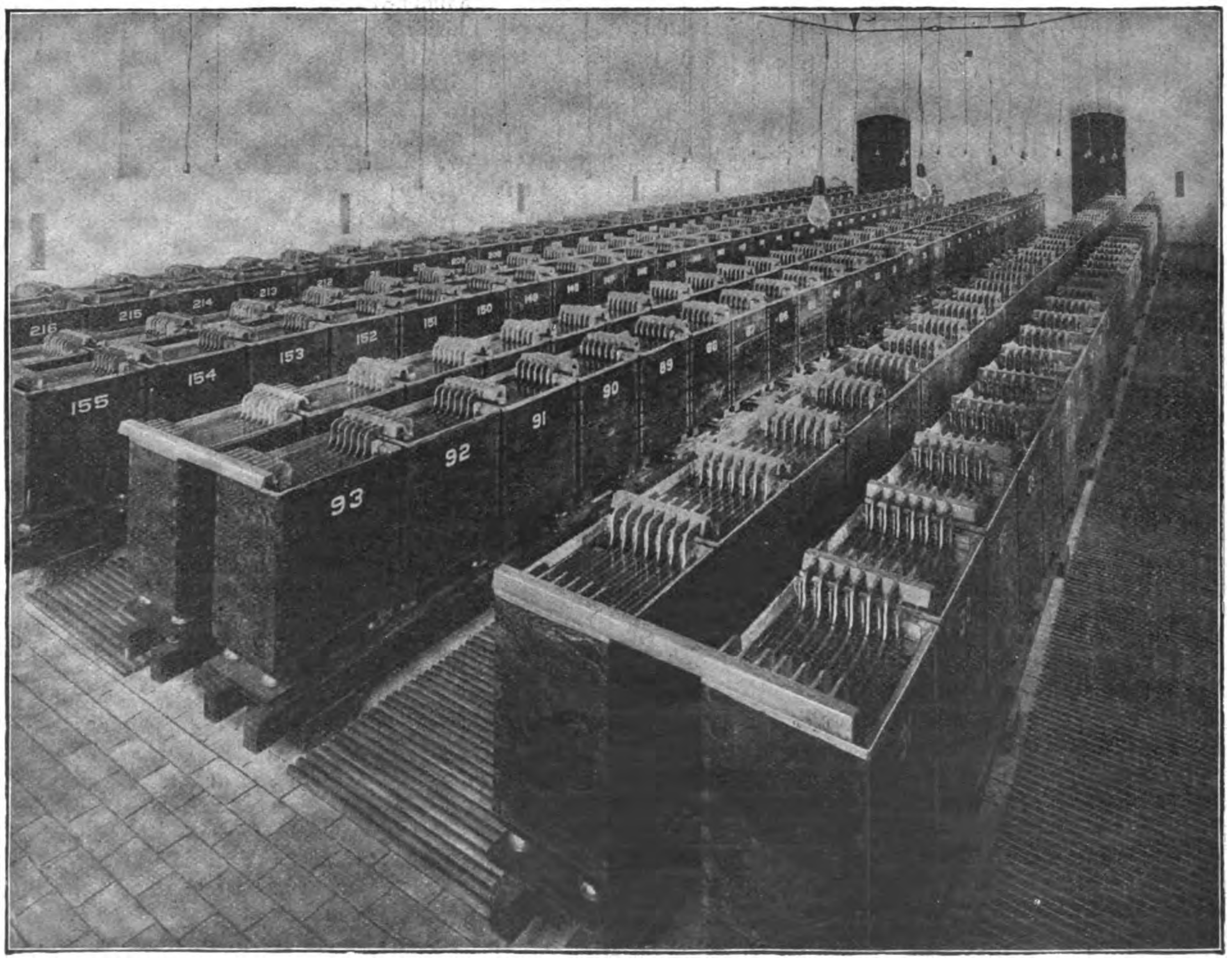
The accompanying illustration gives a view of a storage battery auxiliary recently installed by the Electric Storage Battery Company, Drexel Building, Philadelphia, for the Union Traction Company of Philadelphia.

The battery consists of 248 cells of "G" chloride type, each cell containing 13 plates. The maximum discharge rate of the battery is 400 HP for one hour. The plates are contained in lead-lined boxes, mounted on two tiers of oil insulators. The connections are made by one continuous weld, no mechanical contact being used throughout the battery.

The switchboard consists of three panels, one each for the battery, feeder and line. The switchboard apparatus is very simple, consisting only of an ammeter, circuit breaker and knife switch in each of the three circuits, together with a voltmeter and recording wattmeters in the battery circuit.

The load on the section to which the battery is connected varies from 100 to 700 amperes; the feeder carries a constant load of 400 amperes, the battery discharging or charging to the extent necessary to maintain this condition. The result in actual practice is found to be that the feeder load remains constant at this average current, and is absolutely independent of the fluctuating demand on the line.

The plant here illustrated is situated at the end of a feeder eleven miles long, on one of the most important lines of the Union Traction Company, of Philadelphia. This year it was decided to extend the line several miles, and it was found that it would be necessary either to build a new power house or install a battery sub-station, as the re-



ELECTRIC RAILWAY STORAGE BATTERY PLANT.

quired addition to the existing feeder system would necessitate such an enormous outlay for copper as to render it commercially impossible.

It was found that the cost of copper alone to carry out this extension and double the service on the section, would be four or five times the total cost of a battery installation to fully meet all the requirements; and that a new power house was out of the question on account of the heavy operating expenses. Before the extension was made the pressure at the end of the feeder was barely enough to operate cars on schedule time, and the pressure varied as much as fifty per cent. A chart taken from a recording voltmeter illustrates the effect of the battery as a regulator of pressure. During four hours, between 1 A.M. and 5 A.M., the only time when the battery is taken off the system, the fluctuation in pressure is very marked. The current curve, taken under normal conditions, shows that the battery provides for fluctuations of several hundred horse power, but can be worked up to 800 HP in cases of necessity.

Such a battery as the above enables railway generators to run always at full load, and, consequently, at the highest point of efficiency, and to act as a cushion to the engine in the event of the circuit breaker opening when trouble occurs on the line. By the use of a properly proportioned battery the capacity of the generating units employed can be limited to the requirements of the average load only, instead of the maximum, the difference being taken care of by the battery. This usually means a saving of thirty to forty per cent. in the capacity of the units, and, moreover, relieves the machinery from excessive strain, due to sudden fluctuations of load.

One of the most valuable functions of the battery is to provide a reserve in case of breakdown, being capable of carrying the total load for a short period. This, in itself, renders the storage battery invaluable to operators of electric railways. When applied to electric railways the battery can be located either in the power house for regulating purposes, or at the end of long feeders, to supply the variable demand, the feeder capacity being equal to the average load only.

THE PORTER-ALLEN ENGINE.

In connection with the article on "Steam Engines for Electric Railway Service," which appeared in our October issue, we are enabled to add a brief description of another type of engine which is used largely in this service. This is the Porter-Allen automatic engine, built by the Southwark Foundry & Machine Company, of Philadelphia, Pa.

Prominent among the points of merit claimed for this engine are its heavy, substantial construction; ability to regulate closely under sudden and great changes in load; economy in the use of steam, and small floor space occupied.

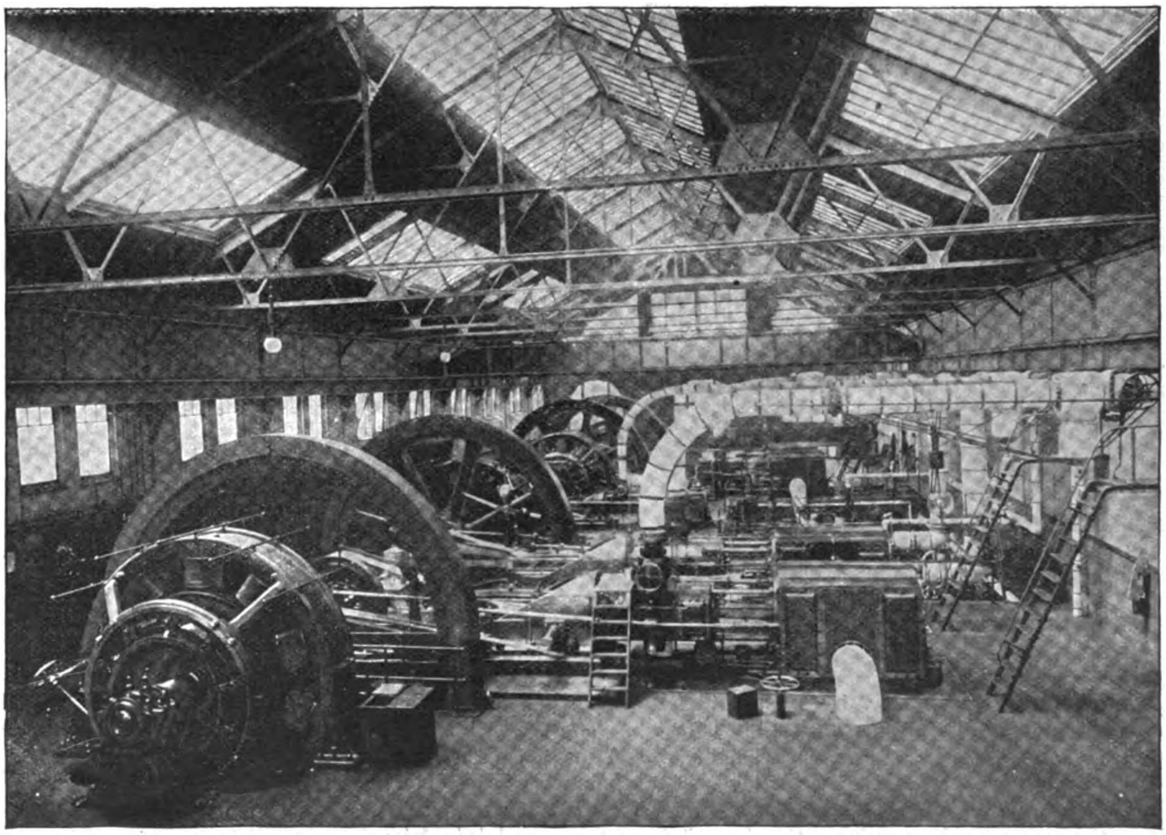
The bed-plate is one heavy piece with broad base, which permits it to be securely held to the foundation masonry, thus providing an absolutely rigid structure upon which to carry the working parts of the engine, and sufficiently strong to overcome all vibration. This feature, coupled with the fact that the bearings are all liberally proportioned so as to reduce the pressure on the wearing surfaces, insures uniformly cool bearings.

The cylinder is firmly bolted to the hood end of the bed-plate, in such a manner as to allow, under changes in temperature, free expansion and contraction in the direction of its length. The clearance is very small in proportion to the piston displacement, and, in addition, is neutralized by compression, which is carried up to the initial pressure of the steam, and remains constant under all changes of load.

The valves are four in number, two for admission and two for exhaust, and are balanced by pressure plates. Each admission pressure plate may be lifted from the valve by means of a screw and check nut, and the plates may be adjusted to exactly the amount necessary to prevent leakage.

The valves are very light, and each opens its port simultaneously at four points. The pull of the valve rod on the valve is central, so that unequal wear is avoided, and by means of the adjusting screw above referred to, the valve may be kept permanently tight. The pressure plates, carrying with them the valves, will be lifted from the valve seat whenever the pressure in the cylinder exceeds that in the valve chest, thus preventing any damage from water which might be carried into the cylinder.

The valve gear is a distinctive feature of this engine. By means of a link actuated by a single eccentric, separate and independent movements are given to the admission and the exhaust valves. It operates with uniform precision, without possibility of uncertain or irregular action. The valve gear joint pins and bushings are made of hardened steel, ground to a fit.



PORTER-ALLEN ENGINES.

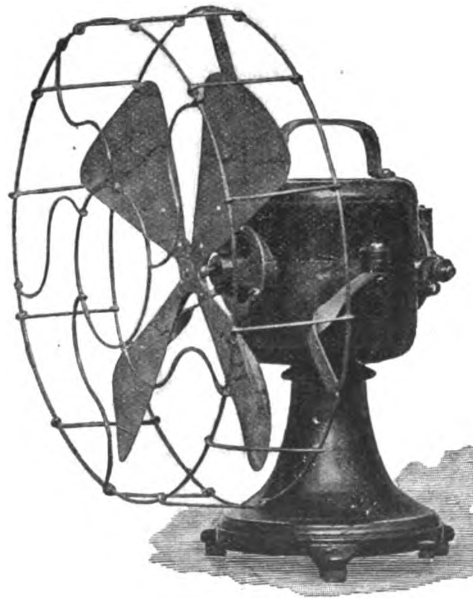
A unique feature of the engine is the governor. It is extremely powerful and, at the same time, positive in its action. The active parts are very light, the power being derived from a high rotative speed, thus causing a sensitiveness in its movements that will arrest fluctuations and produce uniformity in the running of the engine. The lubrication of the engine is automatic and continuous, stationary sight-feed oil cups being used throughout, which may be filled while the engine is running.

The accompanying illustration shows the power house of the Electric Traction Company, of Philadelphia, which is fitted up exclusively with Porter-Allen engines. The plant consists of four tandem compound, condensing engines, of 1100 HP each, direct connected to General Electric generators. These engines have high pressure cylinders 24 ins. in diameter, low pressure, 46 ins. in diameter, with a stroke of 42 ins., and a speed of 120 r. p. m. There is also one 400-HP engine of the same style, 14½ ins. and 26 ins. × 24 ins., running at 200 r. p. m. The steam pressure carried is 125 lbs. per square inch.

These engines are built either horizontal or vertical, simple, compound or triple, condensing or non-condensing, and are in use in many other power stations throughout the country.

A NEW FAN MOTOR.

Fan motors are usually put under way some months in advance of the season when they will be used, and one now being gotten ready for the market is shown in the accompanying illustration. The new motor, which is called the "Paragon" has two speeds, 2000 r. p. m. at full speed and 1500 r. p. m., and does not heat at the highest rate though run continuously for hours. The motor is made for direct current circuits. It has a 12-section armature, a lock nut commutator, is mica insulated, and built as carefully as a large dynamo.



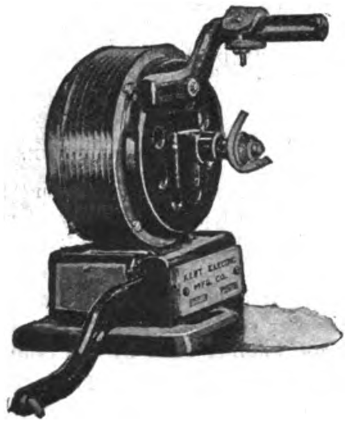
PARAGON FAN MOTOR.

The Paragon motor, which is made by J. P. Williams, 39 Cortlandt Street, New Vork, will be made in three sizes—12 ins., 14 ins. and 16 ins.

AN ALTERNATING CURRENT SEWING MACHINE MOTOR.

The motor illustrated herewith has been designed to supply the demand long existing for a sewing machine motor for use with alternating currents, which will have sufficient starting torque to start readily with a load.

The motor is of the induction type, with neither commutator nor brushes. It is mounted on a base which is moved by a lever connected with the sewing machine treadle, whereby the belt transmitting power from the motor to the machine can be slacked when necessary or vice versa. It is provided with a switch which is turned on when the operator sits down to the machine. The motor pulley is running constantly when the machine is in use and the speed may be varied from the lowest to the highest by merely moving the treadle. Upon shutting off the power a brake is applied to the balance wheel, which stops the latter instantly.



SEWING MACHINE MOTOR.

ARC LAMP CLUTCH.

The accompanying illustration shows a new, and improved clutch for Brush and T.-H. arc lamps. Among the features of the new clutch are its method of adjustment whereby closer regulation can be obtained. The clutch is easily and quickly applied to the above styles of lamps, and, it is claimed, renders slipping of the rod impossible, while the life is longer than that of the usual form of this mechanism.

ARC LAMP CLUTCH.

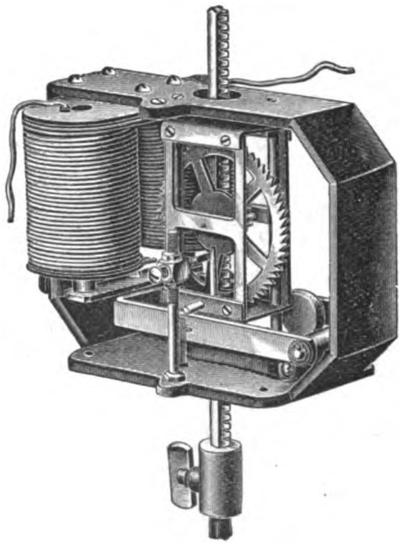
The above described clutch is made by the Philadelphia Electrical & Manufacturing Company, Twentieth and Jones Streets, Philadelphia.

NEW ARC LAMP MECHANISM.

A new lamp mechanism, illustrated herewith, is that of the Ajax enclosed arc lamp, discribed in our October issue. A rack feed was selected for the Ajax lamp because of the advantages possessed by this construction for lamps which are inspected and cleaned only at long and irregular intervals, which custom usually prevails where long-burning lamps are used. The rack feed, of itself, is a simple and positive mechanism, but the train of gears with which so many lamps have been burdened heretofore has been the source of much annoyance in no way chargeable to the rack and pinion.

There is no gearing used in the Ajax lamp except the one pinion which engages loosely the rack rod, and supports the latter at a position determined by the strength of the series solenoid. By reference to the cut it will be seen that there can be no slipping of the carbon rod nor any feeding of the upper carbon until the vertical or vibrating pin falls below the horizontal adjustable pin, through the consumption of the carbons and the consequent lowering of the cores of the solenoid.

This positive feed feature well qualifies it for use in locations where there is considerable vibration, such as in mills, where looms or heavy machinery cause a continual jarring, on steamboats, etc. Notwithstanding its great stability, the feeding mechanism is sensitive to the smallest variation of potential at the arc, and as long as the rack rod is approximately clean, the feeding is accomplished by inappreciable increments, through the medium of gravity and a weighted escapement pawl which vibrates very slowly. As there are no close fitting or finely adjusted parts in an Ajax lamp, it is claimed that ordinary care at long intervals will suffice to keep it in excellent working order.



AJAX ARC LAMP MECHANISM.

This lamp is well constructed, having a case hardened pawl, all steel parts being well nickeled to prevent rusting, and is manufactured by Pomeroy, Woltmann & Company, 43 Cortlandt Street, New York.

ELECTRICAL INSULATION.

That the question of insulation is a very important one in the electrical trade and its allied lines, is evident from the many efforts which have been made to secure a preparation which would insure perfect insulation as a reasonable cost. There has recently been issued by the California Asphalt Company, 57 East 59th Street, New York, a pamphlet under the title of "Alcatraz Electrical Compound," setting forth briefly the merits of this product, which is offered as the solution of what has hitherto been a perplexing problem in electrical construction. "Alcatraz Electrical Compound" uses as a base the well-known brand of Alcatraz asphalt, mined in the southern portion of California—a product which has been used with great success all over the United States.

This compound penetrates thoroughly, dries quickly, and adheres tenaciously, thereby avoiding waste in the transmission of electrical energy. It presents a smooth surface without being sticky, prevents corrosion, and is not affected by salt water, moisture, alkalis, acids, etc. For this reason it has proven particularly valuable in water-proofing, cut-out boxes, painting wires where subjected to acid aud alkaline fumes, etc., and also as a covering for brackets and poles. It is claimed to be not affected by climatic or thermal changes and has been used with marked success in various parts of the country. The pamphlet, together with other information relating to the subject, may be obtained upon application to C. P. Williams, No. 39 and 41 Cortlandt Street, New York.

AUTOMATIC WEIGHING MACHINE.

The Pratt & Whitney Company is now placing on the market a new automatic weighing machine with an improved power feed device which enables any kind of material to be handled. This machine operates upon a new principle, and is pronounced by the makers to be a radical advance upon any weighing machine offered to the trade.

The machine is constructed on the interlocking principle, making it impossible for any material that is being weighed to pass through the machine without being accounted for by means of a register or counter, positively connected with the machine. All material that will spout freely by gravity can be handled through the machine without being forced in delivery; but for such substances as coal, flour, cement, fertilizers of different kinds, cotton-seed, cotton-seed-meal, and articles of similar nature, an automatic power feed device has been provided. This device consists of a short horizontal steel apron-conveyor actuated by a belt and pulleys, which conveys the material to be weighed into the bucket of the weighing machine. This conveyor is capable of different speeds, a fast speed delivering about 90 per cent. of the load to be weighed into the bucket, after which, assisted by an ingenious shaking device, the remaining 10 per cent. of the full load is made up; and when the accurate full weight is delivered into the bucket the conveyor stops automatically, a valve catches the drip from the apron, and the load in the bucket is dumped, after which the operation as described is automatically repeated.

These machines are all equipped with a new counter or registering device positive in its workings, and absolutely correct in its count, and is so connected with the machine that it is impossible to operate one without operating both.

This scale, adapted for all purposes, is made in many sizes; it can be set for any weight, and has registering devices, with stop motion checks, so that it may be set to measure any weight, and then cease measuring when the determined number of weighings has been measured and registered, all automatically, and without error in either weights or in number of weighings delivered. The company is equipping large power plants with machines for weighing coal for storage, as well as weighing the coal from the storage bins for delivery to the boilers, either through automatic stoker or otherwise, and registering the amount of coal consumed by each boiler to which the machine is attached within a given time. A machine is now in operation in Chicago, which weighs and delivers 90 to 100 tons per hour of crushed bituminous coal to the furnace of the Chicago Sugar Refinery Company; another order shipped to the Edison Illuminating Company, of the same city, was for six scales for weighing coal to the boilers of that company.

PERSONAL.

Mr. Thos. J. Fay, for a number of years the New York representative and late manager of the C. & C. Electric Company, has severed his connection with that company and will open an office as consulting electrical engineer. Mr. Fay has been long and favorably known to the electrical profession, and his advent in the new field he has chosen will be a decided acquisition to it.

Mr. I. H. Sherwood has recently been added to the force of instructors of The Correspondence School of Technology, Cleveland, O. Mr. Sherwood is a graduate of Case School of Applied Science. He learned the trade of machinist before going to College, and while there worked as a machinist and as an engineer. He is now a licensed stationary engineer, and also assistant instructor in the electrical engineering course of the Cleveland Young Men's Christian Association. Mr. Sherwood's own experience enables him to fully appreciate, not only the value of an education, but also the trials and difficulties encountered by those who have to obtain an education through their own efforts.

Messrs. Hasson & Hunt, the California firm of electrical and mechanical engineers, are the subject of a leading article in a recent special edition of the San Francisco *Journal of Commerce*. Among the plants named for which they have acted as engineers are the transmission plant of the Consolidated Mine at Bodie, and the Sacramento-Folsom, and Nevada County transmission plants. The firm has also investigated and reported on the feasibility of developing large quantities of permanent water power in the vicinity of Fresno, Porterville, Bakersfield, Kern River, San Gabriel River, Mokelumne River and McCloud River. The plant at Fresno has already been installed and those at Bakersfield and Kern River are in process of installation. During the past year the firm had charge, as consulting engineers, of the work of changing the entire cable systems of Los Angeles Street Railway Company from cable to trolley, and is now engaged preparing plans and procuring proposals for a hydraulic and electric plant for the Mountain Mines Company of Shasta County.

NEW BOOKS.

A PRACTICAL HANDBOOK ON THE CARE AND MANAGEMENT OF GAS ENGINES. By C. Lieckfield.

The price of this book, of which a notice appeared in the October issue, was erroneously given as 75 cents. The correct price is $1.

"PRACTICAL ENGINEER" POCKET BOOK FOR 1897. Edited by William H. Fowler, Manchester: Technical Publishing Company. 343 pages, illustrated. Price, 1s. 6d.

The eighth issue of this annual, published from the office of our English contemporary, The *Practical Engineer*, has been considerably enlarged by the addition of notes and data relating to electric traction and welding, while the chapter on gas and oil engines has been amplified and brought up to date. While its information is compiled more especially with reference to British practice, the American practical engineer will find it useful from the large number of steam and mechanical tables contained.

THE MINERAL INDUSTRY. Its Statistics, Technology and Trade. Edited by Richard P. Rothwell. New York: The Scientific Publishing Company. 849 pages. Price, $5.

The present volume of this excellent annual brings its record of the statistics, technology and trade of the mineral industry in the United States and other countries to the end of 1895. Electricity is represented under a number of heads, such as coal-cutting, haulage, furnaces, hoisting, mining, power transmission, pumping, rock drills, ventilation, welding, etc. Important sections of the book are devoted to electrolytic refining, those on copper and silver processes and plants being notably instructive.

ALTERNATING CURRENTS AND ALTERNATING CURRENT MACHINERY; Being Vol. II. of Text-book on Electromagnetism and the Construction of Dynamos. By Dugald C. Jackson, C. E., and John P. Jackson, M. E. New York: The Macmillan Company. 729 pages, 334 illustrations. Price, $3.50.

This volume takes up the principles of alternating currents which enter into the design and operation of alternators, transformers and alternating current motors. Under the first head are treated windings, the magnetic circuit, characteristics, regulation, output, efficiencies, etc. Under transformers are chapters on mutual inductance, iron and copper losses, efficiencies, design, etc. All of the various forms of alternating current motors are considered, and there are chapters on polyphased transformers and the measurement of power in polyphased circuits. This work is undoubtedly the best yet written on the subjects of which it treats, the authors viewing everything from the practical standpoint, as far as that is possible in a professed text-book. Its reading requires a knowledge of elementary calculus.

TRADE PUBLICATIONS.

Fan Motors. J. P. Williams, 39 Cortlandt Street, New York, in anticipation of the coming fan season, has issued a catalogue of the "Paragon" fan motor. This is of the iron-clad type, and is claimed to be highly efficient and entirely noiseless in operation.

Leather Belting. In a handsome 24-page pamphlet, Chas. A. Schieren & Company, of 45 Ferry Street, New York, give views of their various office buildings, and photographic reproductions showing in rolls some of the monster belts they have turned out. Among these are four rolls of 72-in. belting, aggregating 534 ft., and three rolls of 64-in. belting, aggregating 590 ft.

Corliss Engines. The Ranken & Fritsch Foundry & Machine Company, of St. Louis, Mo., in a new catalogue, illustrates and describes its horizontal and vertical types of Corliss engines. The various details of the engine are separately illustrated and described, the pamphlet in this respect being a concise and practical technical treatise on modern engine design and building.

Steam and Water Specialties. The Monash-Younker Company, 201 Canal Street, Chicago, is sending out a wallet containing two catalogues—one of steam and water specialties and the other of the fittings employed in its new method of connecting lead pipe without the necessity of soldering or wiping the joints. The wallet is strongly made and suitable for containing letters and memoranda that otherwise would be carried loose in the pocket.

Light Cars. The Sheffield Car Company, Three Rivers, Mich., in a 96-page catalogue illustrates numerous kinds of light cars, including all varieties of hand track cars for workshop use in transferring work and material. The equalizing electric motor truck of this company is especially designed to lessen the wear on rails by minimizing the force of the blow at the joints. The truck is adapted for either single or double reduction motors.

Self-Cooling Condensers. In a 24-page pamphlet, issued by Henry R. Worthington, 86 Liberty Street, New York, a very complete and well-illustrated discription is given of the Worthington self-cooling condenser, which produces a vacuum without natural water supply. As a treatise on the subject of condensation by the self-cooling method, now entering largely into practice, this little pamphlet will interest all engineers and others having to deal with steam utilization.

Sewing Machine and Battery Motors. The Kent Electric Manufacturing Company, of Worcester, Mass., has issued a descriptive catalogue of its new alternating-current sewing machine, fan and battery motors. By means of the former and its attachments a sewing machine can be run at any speed, from the highest to the lowest, and started with full-load torque. The fan motors are of both the induction type for alternating currents, and continuous current type for battery currents.

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BUSINESS NEWS.

The Partridge Carbon Company, of Sandusky, O., had a fine display of motor carbons at the St. Louis Convention. The secretary of the company, Mr. J. S. Speer, was in attendance.

Mr. W. F. Richardson, formerly of the Metropolitan Electric Company, of Chicago, is now acting as manufacturers' agent for rubber wires and cables, electrical supplies, etc. His address is 1436 Monadnock Block, Chicago.

The Crane Company, of Chicago, exhibited at the American Street Railway Convention some of its high pressure valves, including one of the largest ever made. The exhibit received a great deal of attention from street railway men. Messrs. Berryman and Hurd were in attandance.

The Ohio Brass Company, of Mansfield, O., had a very elaborate display at the Street Railway Convention of everything used in overhead electric railway construction. Mr. C. K. King, secretary of the company, was present, together with Mr. Arthur L. Wilkinson.

The Heine Safety Boiler Company, St. Louis, made a fine display at the recent Street Railway Convention in that city of a full sized boiler; also a working model of the well known Heine pattern. A neat aluminum souvenir was given away, on one side of which was the legend "Helios holds the record on evaporation. We come next."

The Westinghouse Machine Company recently received through its Paris branch an order for a 1200-HP engine, similar to those exhibited by that company at the World's Fair, which would seem to indicate that some features of the great Exposition made substantial and lasting impressions on foreign visitors. The engine is to be used in an electric lighting station in France.

The Western Telephone Construction Company, Chicago, had its interests well looked after at the St. Louis Convention by Mr. Chas. P. Platt. The exhibit consisted of a very handsome switchboard, together with various forms of telephones and appliances. This company is making a telephone system especially adapted to the needs of street railway companies, and is meeting with the best of success.

The Stromberg-Carlson Telephone Manufacturing Company, Chicago, has removed its office and factory from 172-174 S. Clinton Street, to the new building at the corner of Jackson Boulevard and Clinton Streets. This change was made necessary owing to the increased business of the company and the great need for better facilities. Additional machinery has been put in and the increased floor space will enable the company to facilitate its business in every way.

The Electric Appliance Company has recently furnished a special order of 5000 ft. of armorite iron armored interior conduit specially painted while hot with a compound designed to protect the iron pipe from rust and corrosion. While this protection is not generally necessary in using iron armored conduit, it seemed desirable in this particular case, and experts have pronounced this carload of conduit to be the finest lot of iron armored conduit that has been seen in Chicago.

The Chicago Insulated Wire Company, Chicago, exhibited at the Street Railway Convention last month an excellent display of weather-proof wire and cables. An attractive feature of the exhibit was a pyramid twelve feet in height. The company showed line and feeder wires from the smallest sizes to cables of 500,000 CM. An exhibit was also made of some handsome reels of magnet wire. Mr. Wm. M. Smith, the treasurer, was in attendance and distributed neat souvenirs in the form of small spools of fine silk magnet wire.

The Emerson Electric Manufacturing Company. St. Louis, has just removed to 718 St. Charles Street, The new quarters are large and commodious, a whole floor being occupied with offices, machinery, tools, etc. The new location is much more desirable than the former one, and affords the company every facility for conducting its business to better advantage. Among the work with which the company has been especially busy of late, is that of making several switchboards. The company is very much pleased with the outlook for future business.

Lounsbury & Company, Chicago, report an encouraging increase of inquiries and orders for electric chain hoists, one of their specialties; also an increased demand for their dynamos and motors. The Portland & Middletown Bridge Company, which operates the bridge across the Connecticut River at Middletown, Conn., has applied electricity to raise the bridge gates by using two Lounsbury electric chain hoists of 6000 lbs. capacity each. This is the first application of electricity for this service, and is considered novel as well as practical.

Saving of Fuel. The C. & B. Attachment Company, of 10 Warren Street, New York, has received a flattering letter from the Anniston (Ala.) Gas & Light Company, concerning the success attained in the use of the C. & B. boiler attachment. "One of our boilers on which this attachment was placed," the letter states, "was under fire continually for several months when the plant was first erected, owing to the fact that we had no other boiler to put in use. During that time a coating of scale was formed, which, in spite of our efforts, we were unable to remove until your attachment was put in position, and now the boiler is entirely clean, and this without the use of any compound whatever since the change. As soon as I can make arrangements I shall have you place one of these attachments on our remaining boiler."

K. McLennan & Company, of Chicago, manufacturers of Gale's commutator compound, had in attendance at the St. Louis Convention its manager, Mr. M. J. Isaacs. Mr. Isaacs made a decided hit in distributing an advertisement in the shape of a state warrant. A display was made of samples of the commutator compound, and samples were given away to everyone interested. Since the Convention the shipments of commutator compound have been large, particularly to new territory, chiefly Canada. The street railway companies of St. Louis have adopted the compound, and their adoption can be traced directly to the result of a trial of a free sample stick obtained at the Convention. Mr. Isaacs invites all users of generators and motors to send for a free sample stick of the compound and test it for overcoming the sparking and cutting of their commutators.

The Sunbeam Incandescent Lamp Company, Chicago, makes an important announcement to the effect that it has arranged to sell its entire output of lamps through the Western Electric Company, Chicago. The Western Electric Company is known throughout the world, and with its unequaled selling organization this arrangement should prove to be of great benefit to the Sunbeam Company. The business will be done in the name of the Sunbeam Company which will therefore still keep its identity, but its sales department will be removed to the Western Electric Company's building, No. 242 S. Jefferson Street. The same announcement gives the information that the new factory at Desplaines, Ill., is now in full operation and that the most modern machinery and apparatus used in lamp manufacturing have been added in every department, making the factory one of the most complete in existence. Its capacity is already being taxed to take care of its increasing business.

Messrs. Bryan & Humphrey, consulting mechanical and electrical engineers, Turner Building, St. Louis, find business quite satisfactory in spite of the prevailing depression. They have just made an investigation and report on a 2000-HP steam plant at Columbus, O., where after making a few changes in the arrangement and operation of the plant, the fuel efficiency was increased nearly 40 per cent. They also have recently finished or have in hand boiler and engine work as follows: Laclede Car Company, Herf & Frerich's Chemical Company, Consumer's Brewing Company, St. Louis Sanitary Company, Fraternal Building, John O'Brien Boiler Works Company, Hitchcock Buildings, all of St. Louis; Edwardsville (Ill.) Electric Light & Power Company, Rich Hill (Mo.) Milling Company, Belleville (Ill.) Gas Light & Coke Company. Electrical work: City of Staunton, Ill., City of Webster Groves, Mo., Dozier Bakery, A. Leschen & Sons Rope Company, St. Louis Iron & Machine Works. Ely-Walker Dry Goods Company, Amplified Electric Company, all of St. Louis. Heating and ventilating: The new St. Louis City Hall, Y. M. C. A. Building, Missouri Medical College, and residences of W. E. Beckman, and L. D. Dozier, all of St. Louis; J. D. Gerlach, Chester, Ill. Also municipal water works plants for the cities of Pacific and Union, Mo. In addition to the above, they have handled a great deal of less important work. They also have in hand the preliminary work for some important electric railway projects.

The American Engine Company, of Bound Brook, N. J., has begun the shipment of its new engines, known to the trade as American-Ball engines. The first of these engines of 100 HP capacity has gone to the Detroit *Evening News* and the second, a 50-HP engine, to the Savannah *News*. Since the addition of this new line of work, the business of the American Engine Company has increased so that it is now compelled to run double time, having installed a night force. In the electrical department, among the recent shipments are the following: Cliff Paper Company, Niagara Falls, N. Y., two motors, 150 HP each; Detroit (Mich.) *Evening News*, two dynamos, each 25 KW; Albany *Morning Express*, Albany, N. Y., one 18-KW dynamo; Oakland (Cal.) *Tribune*, 25-HP motor; A. N. Kellogg Newspaper Company, Chicago, Ill., four 15-HP and one 25-HP motor; Topeka *Capital* Topeka, Kan., 5-HP motor; Boston *Traveler*, 12-HP and 5-HP motor; Worcester (Mass.) *Post*, 9-KW dynamo; Cincinnati *Post*, 35-HP motor; Philadelphia *News*, 25-HP and one 3-HP motor; Elmira *Gazette*, 25-HP motor; American Newspaper Publishing Company, 25-HP motor; Carrington Publishing Company, 1-HP motor; J. B. Cranfill, Waco, Tex., 25-HP motor; Fall River Publishing Company, Fall River, Mass., one 25-HP and 3-HP motor; Saginaw (Mich.) *Evening News*, 12-HP motor; B. A. Meade Company, Augusta, Me., 3-HP motor; Chicago *Journal*, 15-HP motor; Grand Rapids (Mich.) *Democrat*, 15-HP and 3-PH motor; St. Paul (Minn.) *Pioneer Press*, 15-HP motor; Wallace Publishing Company, Des Moines, Ia., 12-HP motor; New York *Tribune*, two 15-HP motors; Rubber Tire Wheel Company, New York, N. Y., 12-HP motor.

◆

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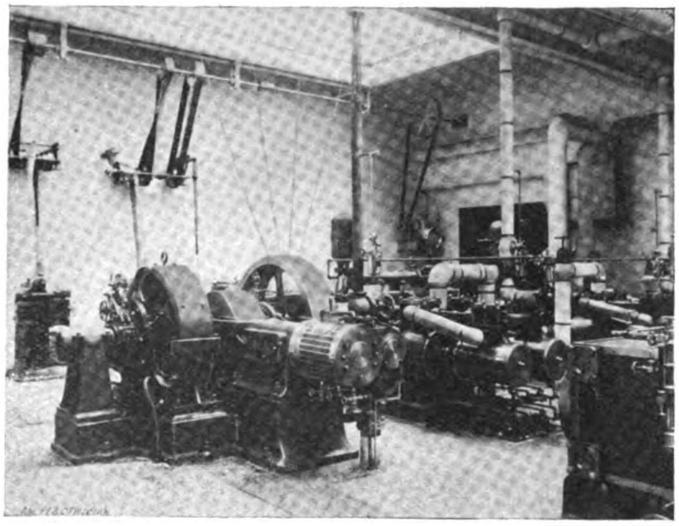
American Electrician.

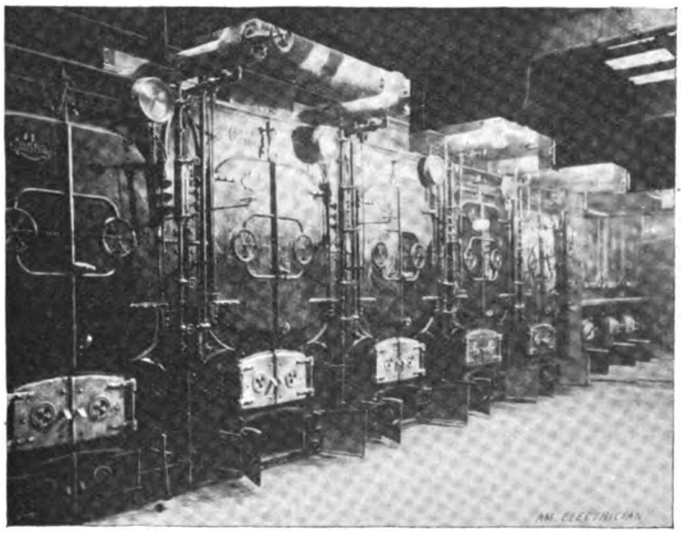
Vol. VIII. New York, December, 1896. No. 8.

ELECTRICITY AT THE COLLEGE OF PHYSICIANS AND SURGEONS.

An extensive application of electricity is found at that branch of Columbia University known as the College of Physicians and Surgeons. Of course, the building is electrically lighted, but electricity is also utilized to furnish power for a number of purposes, and it also has an extensive application in surgery and medicine. The equipment is very complete in all of its details, having been given careful thought.

The source of power is, of course, the boiler room, and it is, therefore, appropriate to describe it first. It consists of a battery of five Tudor boilers, each rated at 60 HP, thus making 300 HP in all. These are simple return tubular affairs, supported in an ordinary brick setting, and are said to do very good work. A newer portion of the steam equipment consists of a pair of the most improved Abendroth & Root water tube boilers, with a full complement of improved fittings, including McClave shaking grates and Locke damper regulators. Each of these boilers has a steaming capacity of 150 HP. A thin pea coal fire is used, and readily maintains a pressure of 110 lbs. of steam, about 5½ to 6 tons being consumed daily. The boilers are fed from a drip tank that derives its chief supply from the condensation of the engines and pumps, the deficiency being made up from the city mains. Thus the water is practically free from foreign material, and no trouble from scale is experienced. The water is fed to the boilers by a pair of duplex pumps, either of which can take care of the feeding alone. This system is supplemented by an injector, and it will be readily seen that the chance of failure of the feed is very small. A general view of the boiler room is shown in Fig. 3, and it will be noted that it is a spa-





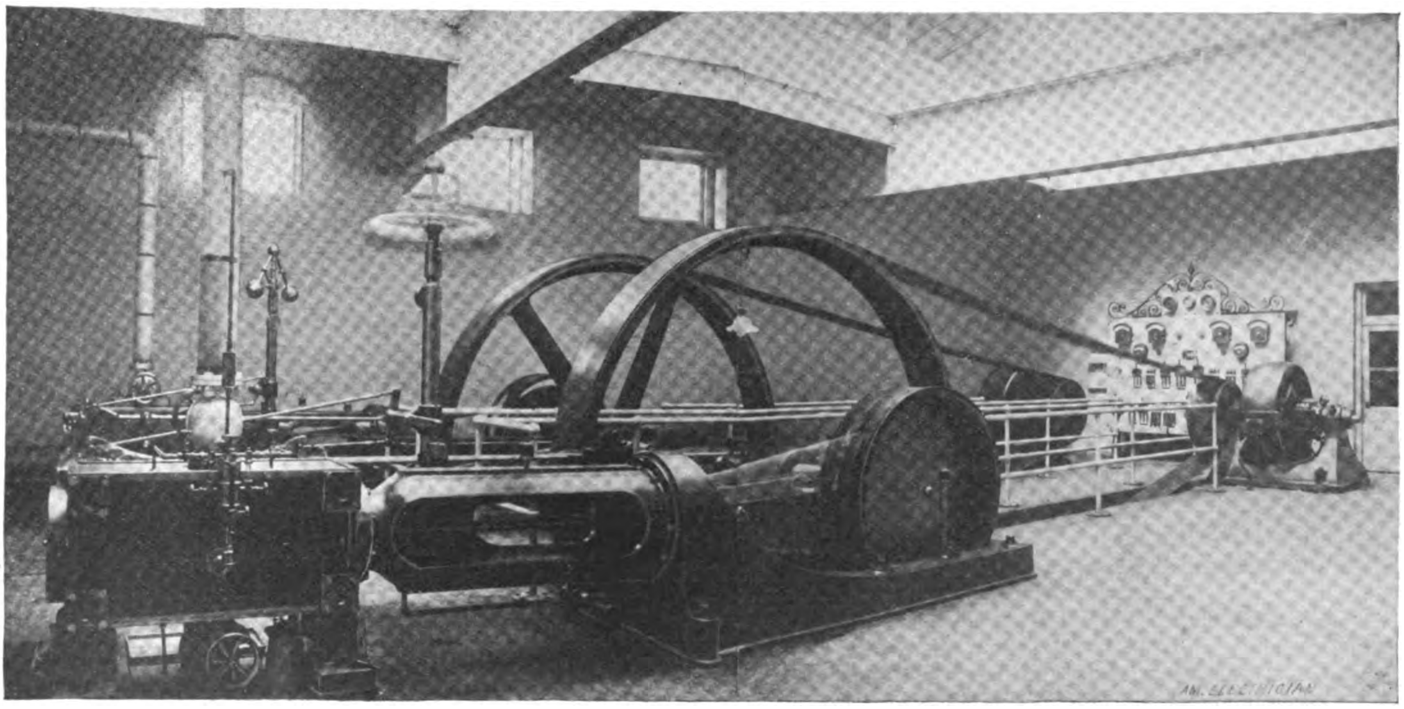


FIG. 1.—DIRECT CONNECTED GENERATOR. FIG. 2.—MAIN GENERATORS. FIG. 3.—BOILER ROOM.

ELECTRICAL GENERATING PLANT OF THE COLLEGE OF PHYSICIANS AND SURGEONS.

ious well lighted apartment, in no way cramped.

The steam which is generated is conveyed through a magnesia-covered steam pipe system which is very ingeniously and effectively drained. A long system of small pipe runs directly under all of the large mains, and is connected therewith at each fitting. Thus all the pockets and other parts of the system are effectively drained, and the condensation is trapped off to the drip tank.

The steam pipe system is so connected that the steam from any boiler can be used with any engine. The large boiler system is used for power and the smaller for heat. The two are connected by a reducing valve, and thus the large boilers can supplement the smaller ones should it prove necessary.

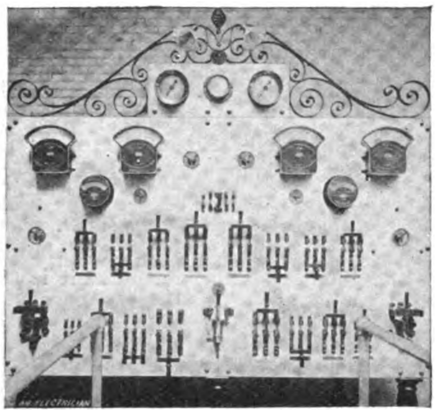


FIG. 4.—MAIN SWITCHBOARD.

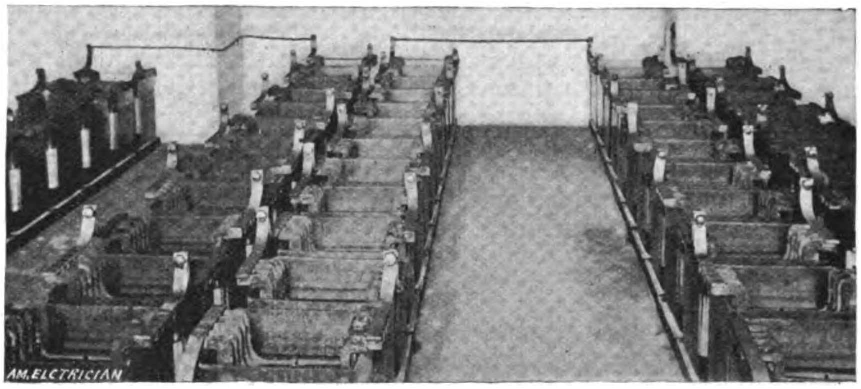


FIG. 5.—STORAGE BATTERY.

The engines consist of a pair of 75-HP. Allis-Corliss engines, and a high speed Ideal engine of about 45 HP. The Corliss engines are identical except that one is right- and the other is left-handed. They run at 92 r. p. m., and have a three-foot stroke and a cylinder diameter of 12 ins. The flywheel is of cast iron and is 12 ft. in diameter with a 17-in. face, upon which operates a 16-in. belt driving a generator. The engines exhaust through a grease extractor into a Goubert feed-water heater, and thence into the heating system of the building. A pump drains the system and serves to relieve the back pressure.

The Ideal engine is about 8 × 12 ins. cylinder dimensions and runs at a speed of 300 r. p. m. This engine is directly connected to a six-pole, 30-KW Crocker-Wheeler generator. This machine is of the drum type with spiral end connectors. It is neat and attractive in appearance and operates very quietly and sparklessly. The belted generators run at 360 revolutions. One is a Crocker-Wheeler machine, and the other is a Walker dynamo. Both are of 50 KW capacity, wound on a 100-KW frame. The Crocker-Wheeler machine has a ring armature, and is of the four-pole type. The winding is a simple Gramme, and four brushes are used. The Walker generator is very similar in general appearance to its mate, but it possesses a number of points of difference. The armature is a drum winding and the barrel system is adopted. The end disk is so shaped that it both supports and protects the ends of the coils, which are thus far removed from the shaft, and free from any grease and dirt. Both machines have self-oiling bearings and are strictly modern products of their class.

The machines operate in multiple, and are connected to the bus bars by three-pole switches; there is also an equalizer switch for each machine. The extra jaw of the three-pole switch carries a second negative wire. The building is wired on the three-wire system, with the neutral twice the size of the other two wires, and as at present connected it forms common wire for the two outside negatives.

A circuit breaker is provided for each machine circuit and there are thirteen sub-circuits. There are three ammeters and one voltmeter and an ammeter and voltmeter for the storage battery plant. The board is supplied with ground detectors and the rheostats are back of the switchboard. The board, which is of white marble and both tastefully decorated and conveniently arranged, is illustrated in Fig. 4.

While not modernized to the extent of entire direct connection, yet the plant operates fully as quietly as the best of any existing plants. From Figs. 1 and 2 it will be seen that the arrangement is above criticism, the room accorded to the apparatus being decidedly superior to the average location allotted to engines and dynamos. In an adjoining room there are a number of pumps to operate the various hydraulic systems of the building. Two of these are compound duplex service pumps delivering directly into a stand pipe; 12 ins. in diameter and 140 ft. high, located in the tower of one of the groups of buildings. The height of the water in the stand pipe, equivalent to 45 lbs., is maintained by the use of a pressure regulator on the pumps. The remaining pump circulates brine for the cooling system in the Sloane Maternity Hospital and the pathological department. The storage battery plant is not very extensive, but is a considerable source of economy aside from supplying an absolutely steady current, such as is needed in electro-therapeutical work. It is shown in Fig. 5, and consists of a battery of 60 chloride accumulators of a capacity of 260 ampere hours.

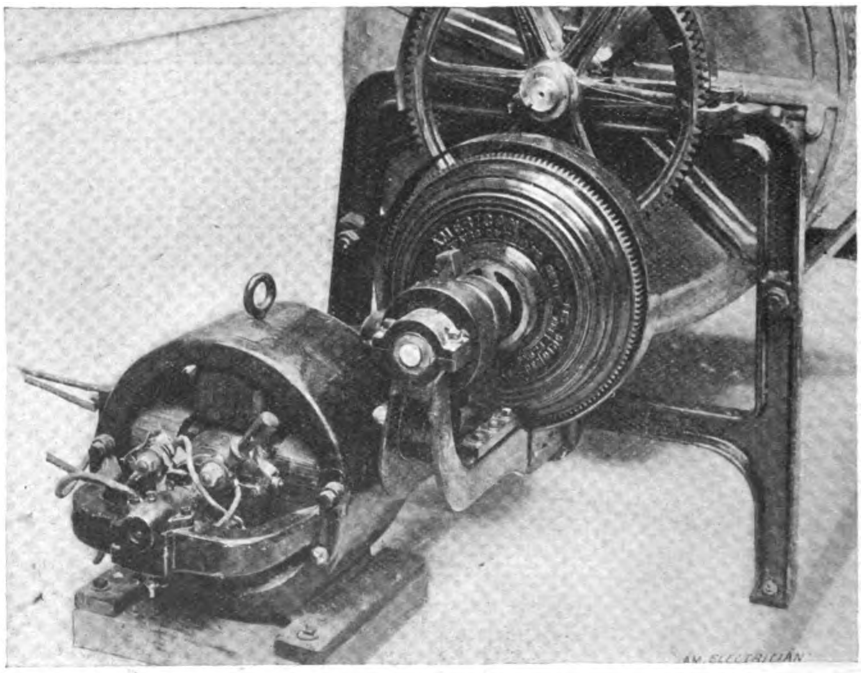


FIG. 6.—ELECTRIC POWER WASHING MACHINE.

The plant is provided with a complete little repair shop consisting of a number of machine tools driven by a C. & C. motor. through the medium of a system of countershafting. This feature is one that, in view of the various kinds of machinery used in large buildings, would there be found an extremely convenient and money-saving adjunct.

The laundry of the Sloane Hospital is interesting in that the several machines therein are electrically driven and directly connected to their motors. The motors are of the Card Cincinnati type, and were adapted to laundry machines made by the American Laundry Machine Company of the same city, which company installed the laundry plant from designs prepared by their mechanical engineer and superintendent, Mr. W. S. Rogers. The washing first passes through a steam washing machine which is given an oscillatory rotating motion by special gearing. This gearing is well illustrated in Fig. 6. A scroll on the outer surface of a clutch operates a worm wheel which reciprocates a shipper and throws the washing drum first in gear to give rotation in one direction, and then change to a reverse rotation.

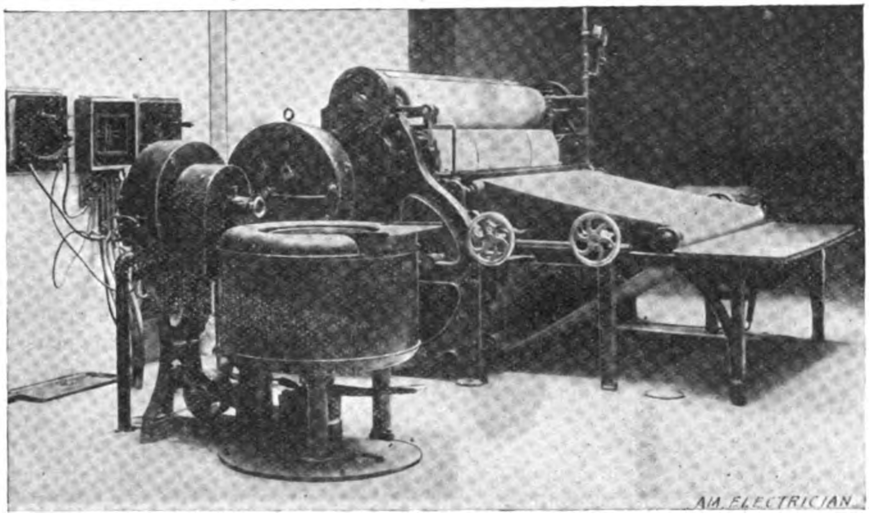


FIG. 7.—ELECTRIC POWER CENTRIFUGAL DRIER.

When the clothes leave the washing machines they are dried in a centrifugal drier which is shown in the foreground of Fig. 7. This compresses them in a mass so compact that they must subsequently be passed through a tumbler (shown in Fig. 8), in order to separate them. The clothes then pass to the ironing machine (shown in Fig. 7). An interesting feature of this machine is that it is driven by a motor of but 3.5 HP and yet the speed is at the extremely low figure of 100 r. p. m. This motor takes 25 amperes at 110 volts. The motor driving the drier runs at 1050 r. p. m., and the other motors have a speed of 600 r. p. m. each. This laundry is the first electrically driven one in the country that is operated by direct connected motors.

The building is ventilated by a system of fans, most of which are directly driven by electric motors. There are in all sixteen fans and ten motors of various makes. An electric elevator completes the list of electrical appliances using moderately large amounts of power. It is of the drum type and driven by one of the original Eickemeyer motors. It is said to give excellent satisfaction. A view of the hoisting apparatus is shown in Fig. 9.

The credit for the design and execution of the entire plant is due to Mr. Edward A. Darling, the superintendent of the buildings and grounds, ably seconded by the assistant engineer, Mr. Frederick A. Goetze, who is now in immediate charge of this group of buildings. Mr. Chas. B. Larson, the engineer in chief, is largely responsible for the creditable appearance and the excellent maintenance which is a feature of this installation.

In the Vanderbilt Clinic connected with the Hospital, there are a number of medical switchboards installed by Freedman, Rennard & Company (Figs. 10, 11, 12 and 15) and by J. C. Vetter & Company (Figs. 13 and 14), which are of much interest.

The electrical currents are supplied to the medical boards by a double-voltage dynamo which closely resembles a rotary transformer for direct currents, except that it is driven by a pulley from an outside source of power.

One commutator supplies current at 110 volts and the other at 10 volts. The currents from this machine are remarkably smooth and have no suggestion of the jagged wave form—often so distressing to patients that a storage battery has to be substituted. This dynamo has a capacity of about 2 HP. Its fields are excited from the 110-volt side, and are highly saturated. Current is distributed to the various boards by means of Kerite wire run in Circular Loom tubing.

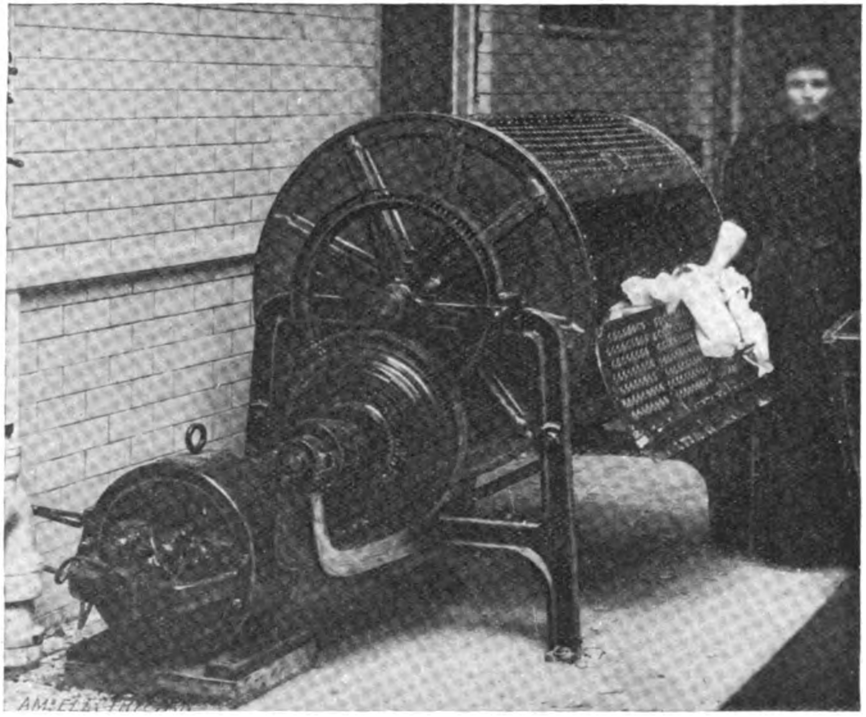


FIG. 8.—ELECTRIC POWER TUMBLER.

There are three principal currents that such switchboards as those just referred to must deliver.

1. A low voltage current in considerable quantity for the purpose of heating the platinum wires of the cauterizing knives to redness.

2. A direct current, the voltage of which can be varied from 0 to a maximum of 100 or more volts. This current is very small and is passed directly through the parts of the system that are affected.

3. An interrupted current of high voltage such as is obtained from a small induction coil. This current is called the "faradic current" by the medical profession, the direct current being named the "galvanic current."

It is needless to say that all of these currents must be under complete control, and the methods of accomplishing this will now be explained in connection with the boards installed by the first mentioned firm.

In Fig. 10 the control of the cautery circuit is shown, which at a glance will be seen to be very simple. The circuit is opened and closed by the button, *A*, and an adjustable resistance, *X*, controls the amount of current that is allowed to pass. This resistance consists of small carbon pencils, about ¼ in. in diameter and 4 ins. long. The resistance may be varied from 0.2 ohm to 10 ohms. The maximum current is 30 amperes.

Fig. 11 illustrates the arrangement for the galvanic circuit. It is opened and closed by an appropriate device at *A*. Two lamps, L_1 and L_2, form a limiting resistance; L_1

has a keyless socket, but L_2 has a keyed socket, and can be thrown on and off at pleasure. All of this current does not flow through the patient, who is placed in a circuit derived from the main circuit at the points a and b. Between these points on the main circuit are two rheostats, and it is obvious that as the resistance of these is adjusted to higher values, the voltage will rise between the points a and b, and thus force more current through the derived circuit. A milliammeter, M, placed in the derived circuit, serves to measure the amount of current the patient is receiving. It will be noted that there are two rheostats. The reason for this is that a single rheostat of an equal number of points would be excessively large, and as compactness is a desideratum, the two are used.

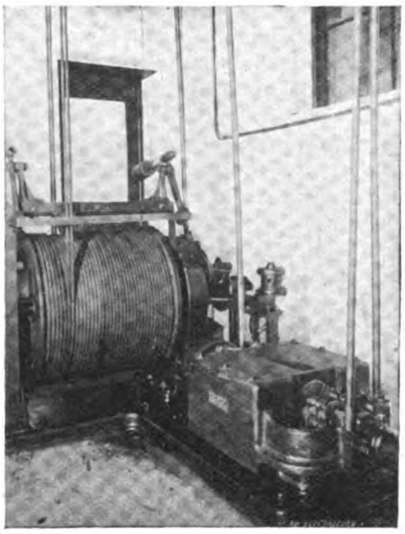


FIG. 9.—ELECTRIC ELEVATOR.

The faradic or induction coil circuit is shown in Fig. 12. Across the 110-volt system are connected in series a lamp, L, the primary of the induction coil and a variable resistance, X. I represents the interrupter, and by adjusting the pressure of a little screw the frequency can be varied. The secondary coil consists of a number of sections, and any number of them can be used, or they may be cut out altogether by the switch, B, thus varying the intensity of the current. The intensity is further varied by R, a Vetter current controller, a very ingenious adjustable resistance. A short rubber tube is filled with powdered carbon, and the ends thereof closed by flat plates which can be forced together by screw pressure. This compresses the carbon and reduces its resistance as a whole. The rubber tube bulges out on either side and accommodates the surplus carbon. When the screw pressure is released, the tube by its elasticity restores the rheostat to its former condition. When it is realized that the current from the induction coil is very small and the resistance of the circuit as a whole is very high, it will at once be realized that the resistance of the controller must vary between wide limits in order to be at all effective. The fact that it is so successfully used for this purpose speaks very well for its extreme range.

The induction coil, C, is also provided with a shield which serves to reduce the inductive effect of the primary on the secondary. By its means a very delicate graduation of the intensity of the current is attained.

In Fig. 13 is shown a Vetter electro-therapeutical wall base, which, when connected with the 110-volt incandescent current, is so constructed as to furnish galvanic and faradic currents, and a combination of both currents.

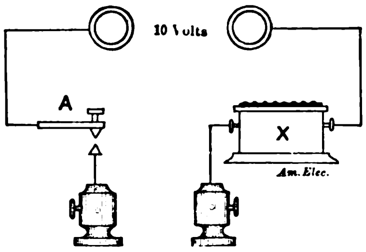


FIG. 10.—DIAGRAM OF CAUTERY CIRCUIT.

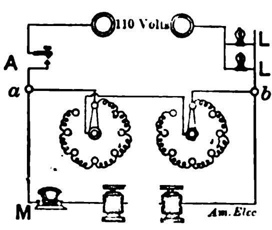


FIG. 11,—DIAGRAM OF GALVANIC CIRCUIT.

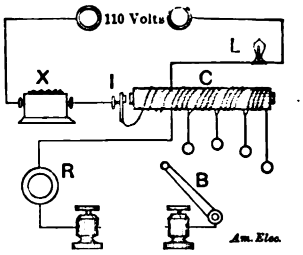


FIG. 12.—DIAGRAM OF FARADIC CIRCUIT.

In applying the galvanic current, the patient is placed in a shunt circuit through the electric light fixture on the top of the wall base, by means of which the voltage of the current can be varied from 20, 40, 60 to 100 volts, according as the candle-power of the lamp in the fixture is changed. The same is applicable to the faradic current, the patient at all times being in a shunt circuit.

The galvanic current is controlled by means of a carbon current controller, described above, and the current passing is indicated on a milliammeter provided with two readings, both having such a range that a fraction of a milliampere can be read. A pole changer is provided for the purpose of changing the polarity at the outlet.

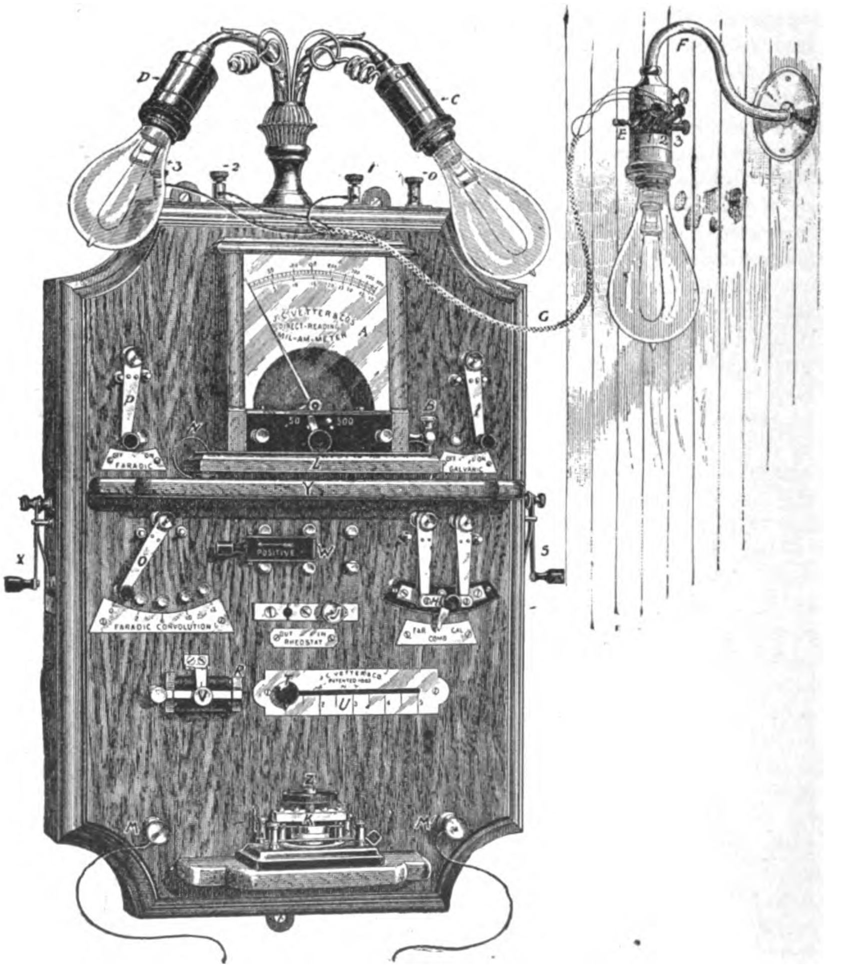


FIG. 13.—ELECTRO-THERAPEUTIC WALL BASE.

The faradic current comes through an induction coil tapped at four different lengths; its quantity can thereby be selected at will by means of a convolution switch, and the current can besides be regulated by means of the helix. When the current-selecting switch is placed in the center, both galvanic and faradic currents can be obtained at once, and be applied to the patient from the same terminals, and increased or decreased at will, so that either current can be made to predominate. The accompanying cuts illustrate the wall base.

The Clinic is also supplied with a Vetter electro-therapeutic cabinet (Fig. 14) which, when connected with the 110-volt current, supplies galvanic, faradic and cautery current and current for diagnostic lamps. It varies particularly from the above described wall base in being provided with volt selectors, by means of which the galvanic current can be selected in single volts from 1 to 110, so that not only the ampereage, but also the voltage, can be controlled in the most minute manner, it being impossible at any time for the voltage of the current applied to exceed the amount for which the volt selector is set.

A small volt selector is also supplied for the faradic current, enabling this current to be modified in various ways: First, by the convolution switch selecting the length of wire; second, by the volt controller selecting the voltage to be used with the current; third, by means of the helix—covering and uncovering the secondary coil, varying the current; and fourth, by the carbon current controller, by means of which the galvanic as well as the faradic current can be modified in the most delicate manner.

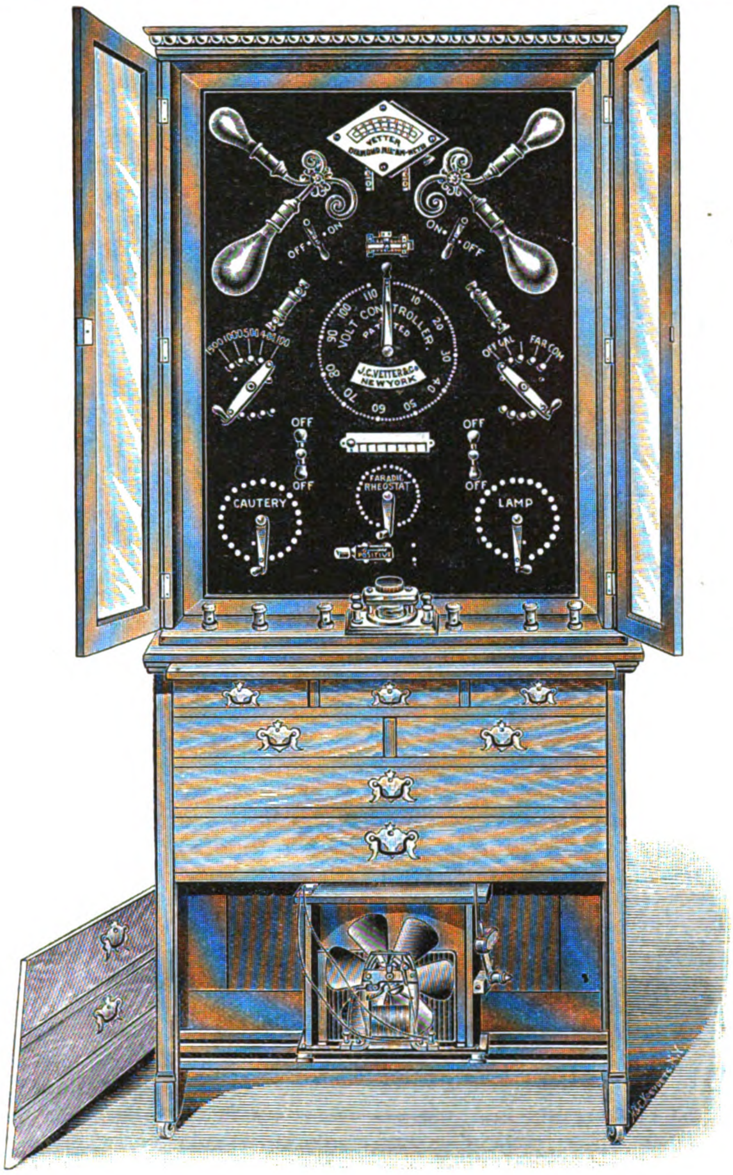


FIG. 14—ELECTRO-THERAPEUTIC CABINET.

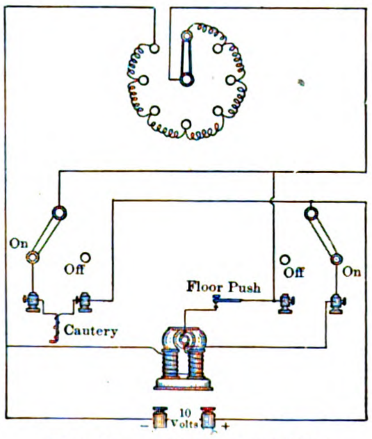


FIG. 15.—SURGICAL MOTOR.

In addition to the above, this cabinet supplies a cautery current sufficient to heat cautery knives and the cautery loop, and at the same time, a current for small diagnostic lamps, such as the electric photophore, cystoscope and others, which may be used at the same time. The lower part of the cabinet contains the motor generator for the cautery current, and also furnishes drawers to hold the various electrodes, etc.

Some of the boards (including the last described) receive their current through a Vetter current adapter. This resembles an ordinary plug, but carries a small switch whereby its free terminals are switched in multiple or series with the lamp. Thus the full voltage or the voltage less the drop in the lamp, may be had at pleasure.

In some of the booths where certain diseases are treated, it is necessary to have a small motor to drive bonesaws and drills and the various surgical hand pieces. This motor is usually connected into the cautery circuit as shown in Fig. 15.

The motor field is connected directly across the 10-volt terminals and the armature is in series with a flow push that connects it in circuit and also with a rheostat that varies its speed. The same rheostat serves to regulate the current that the cauterizer receives.

VOLTMETER MEASUREMENT OF INSULATION RESISTANCE.

BY W. B. HALE.

The results obtained by Mr. Corson in his article on the measurement of insulation resistance by means of a voltmeter, published in the November AMERICAN ELECTRICIAN, while undoubtedly correct, may be reached by a simpler process, and one which will, I think, be more easily remembered and applied by the practical electrician.

He assumes that "the combined resistance of voltmeter and ground is so great that the current flowing through the path will not affect the drop in potential through such conductors as $A B$ and $B C$." This being so, we may consider A, B and C as points having a fixed difference of potential, the sum of these potentials being V.

Now, disregarding the word "volts" as applied to the scale readings, let us consider the voltmeter as a current indicator (which in this case it is). The problem may now be worked out in the following simple manner:

A deflection of 500 divisions on voltmeter scale represents the current resulting when 500 volts are applied to the resistance of the voltmeter, which is, in the example given by Mr. Corson, 60,000 ohms. The *constant* of the voltmeter (that is, the resistance corresponding to a deflection of 1 scale division, with same voltage) is therefore 60,000 $\times$ 500 = 30,000,000 ohms.

Now, if the current through the voltmeter when connected between positive main and ground is represented by 35, and when connected between negative main and ground by 15 scale divisions, the sum of these readings must indicate the current that the entire voltage (500) would send through the voltmeter in series with a resistance equal to that of the ground. And so, referring to our constant,

1 div. deflection = 30,000,000 ohms;

therefore 50 div. deflection = $\frac{30,000,000}{50}$ = 600,000 ohms; and the resistance of the ground is therefore 600,000 — 60,000 = 540,000 ohms.

Any electrician who has occasion to make frequent measurements of insulation resistance with a voltmeter will find this work much simplified by knowing the constant of his instrument for the voltages he commonly meets with. He can then determine such resistances with very considerable accuracy by a simple mental computation. In fact, where the resistance of the voltmeter is small compared with that of the ground, it may be disregarded entirely. The voltmeter will then indicate very closely the resistance of the ground, it being inversely proportional to the deflection of the needle as compared with the constant of the instrument.

Take as an example the voltmeter referred to above. Its constant for a 500-volt circuit is 30 megohms. If a deflection of, say, 6 divisions is obtained when the instrument is connected between one main and ground, it will be seen at a glance that the insulation resistance of the other main is approximately $\frac{30}{6}$ = 5 megohms.

Compressed Air in Railway Work.

BY PROF. WM. S. ALDRICH.

Compressed air has been stated to be the most important rival of electricity for the distribution of power in railway work. There are, no doubt, undisputed fields to which each system is peculiarly applicable—in which one or the other is and will continue to be almost exclusively used, as electricity for light, and compressed air for ventilation and for refrigerating purposes.

For power distribution, however, Prof. Unwin believes that the compressed air system will meet all of the conditions more completely and satisfactorily than any other system hitherto carried out, not excepting the electrical.

For street railway work, also, it is daily becoming more apparent that compressed air has entered the field as the only rival of the electrical system. In other cases of what may be termed light railway service, as in mine haulage, whether on the surface or underground, the compressed air system claims the peculiar advantages of flexibility and the use of entirely independent units of motive power. For light freight service it has also been adopted, as well shown in the illustration (Fig. 1) of the compressed air locomotive used for haulage work among our Southern cotton warehouses and compresses, at the terminal of the New Orleans & Western Railroad, at Port Chalmette, La. This latter example is one of the most complete and satisfactory of the late installations of compressed air for motive power work.

In mine haulage and the transmission of power from a central point to the various mining drills, mining pumps, etc., compressed air has long held an almost undisputed sway. The by-product of such an agent in the transmission of power furnishes cool, fresh air for ventilation and improvement of the atmosphere in the workings. In certain lines of mining also, there is in compressed air work no danger from fire, as has been argued to the disadvantage of the electric transmission. In mining developments through compressed air drills, the fields have been invaded by the electric drill, the electric coal cutter, and at the same time electricity furnishes the most satisfactory light for the various operations in the workings.

It would seem that for general mining work the combination of the two systems might have inherent advantages over either. The compressed air furnishes the motive power for drills, cutters and pumps where most applicable, and at such points as require the most thorough ventilation the air exhaust performs valuable service. Combined with this would be the electric system supplying the needed lighting facilities for mining work. For pumping service in the mine, compressed air will no doubt long continue to be used, notwithstanding its so-called "freezing up" of the exhaust The electric mine pump has not yet been sufficiently developed to replace the ordinary steam pump worked by compressed air.

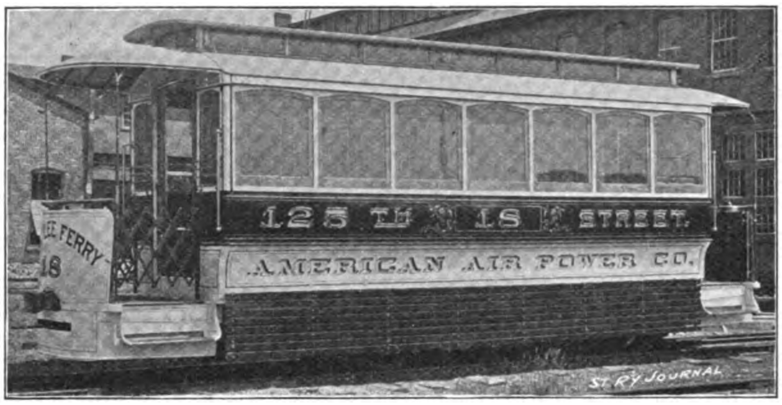


FIG. 1.—HARDIE COMPRESSED AIR CAR.

For surface haulage and motive power, compressed air has certain inherent advantages which have from time to time been more or less brought forward in its advocacy. Chief among these, we believe, will be found to be the independent nature of the motor or motor car. The compressed air in the case of long lines is distributed through suitable pipes or mains placed a few inches below the surface of the roadbed. These are tapped at definite intervals so that the air storage tanks or reservoirs of the motor power can be replenished at such points along the line where recharging will most probably be required. This places each motor car on an independent basis. The service can be thus made use of to the greatest advantage in the most crowded portions of the downtown districts of our large cities.

In general, two charging stations should be provided, one at each end of the line. In some cases, however, it would be only necessary to equip and maintain one charging station near the center of distribution for a downtown district. The frequent stops required in such locations would, of course, necessitate more frequent renewals of air supply than in an outlying district in the suburbs. There is no reason why such compressed air plants should not be located as advantageously with respect to the supply of fuel and condensing water as has been done for the electric railway plant. In fact, there is much less necessity for locating such a generating station near the center of distribution than in the case of the electric plant.

The pressure of air to be utilized for such a distribution becomes a vital question. It is that which in fact has given compressed air very little reputation for power transmission. For in its most frequent use it is not worked expansively in the air motor or engine as in the case of steam, and thus the efficiency diminishes very rapidly with increase of the initial pressure.

The most economical manner of compressing the air is by what is known as *isothermal* compression. Under such conditions the air is taken in at the ordinary pressure and temperature of the atmosphere of the street, let us say, and compressed to four or five atmospheres without any change of its initial temperature. Of course, these conditions are ideal, but they are beginning to be realized more and more in the best of our modern compound air compressors. In these the heating effect due to the compression of the air is counteracted by using a water jacket around the compression cylinder or by injecting a water spray into the

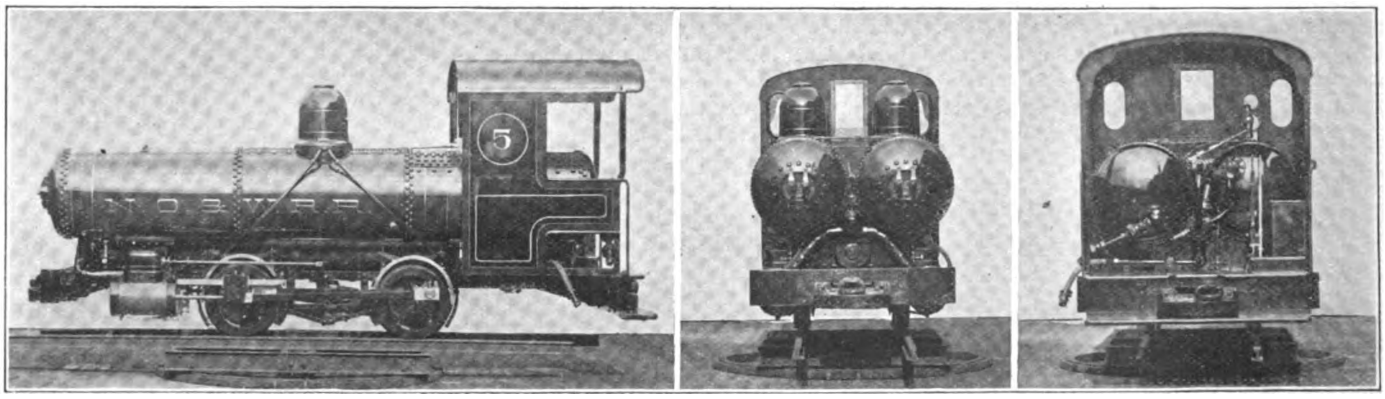


FIG. 2.—PORTER COMPRESSED AIR LOCOMOTIVE.

cylinder during compresssion. Such partially-cooled compression results in an elevation of temperature of from, say, 60 degs. F. of the outside air to 256 degs. F. at the end of the compressive process, when compressing to five atmospheres.

If the compression had been carried on under another ideal condition in which no heat is taken from the air during the compression, the temperature in the last example would have risen to 370 degs. F. Such compression would require to be effected in what is known as a perfectly non-conducting cylinder and would be termed *adiabatic* compression.

These terms, *isothermal* and *adiabatic*, are of very frequent use in speaking of compressed air working and the characteristic features of the process are clearly indicated by the compression lines of the diagram (Fig. 2). We shall have occasion to refer to this at a later time, and at the present merely wish to make clear the meaning of the terms isothermal and adiabatic. If the air is used expansively, as, for instance, in the cylinder of an ordinary engine instead of the steam, the expansion curve would be neither an adiabatic nor an isothermal line, but would fall between the two.

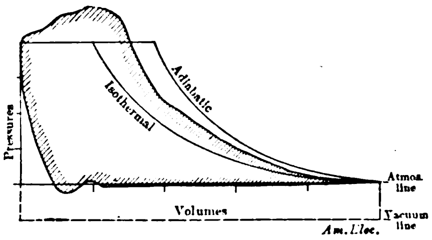


FIG. 2a.—SHOWING THEORETICAL COMPRESSION LINES, ADIABATIC AND ISOTHERMAL, AND ACTUAL CARD.

To expand the air along a perfect isothermal would require the temperature to be maintained the same throughout the whole stroke; and this would require a hot jacket of some kind around the cylinder of an air engine. On the other hand, if the air should be expanded adiabatically in a perfectly non-conducting cylinder, the temperature would, of course, fall throughout the entire process; and if at 60 degs. F. at the beginning of expansion, the theoretical temperature at the end of the stroke would be 176 degs. below zero, expanding from eight atmospheres to one.

Of course, such low temperatures could not be reached in the cast iron cylinders of ordinary air engines on account of the absorption of heat through the walls of the cylinder and from other metallic surfaces with which it would come in contact. It is, however, sufficiently low to cause great inconvenience at the exhaust opening, dependent somewhat upon the amount of moisture in the outside atmosphere. This, with the moisture usually present in the compressed air, produces the "freezing up" of the exhaust ports and passages, and choking the exit of the air sufficiently to even stop the motor.

We are now prepared to consider the ideal efficiency of a combined air compressor and motor. If the air is compressed isothermally and used non-expansively as in rock drills, mining pumps, small air motors and other mechanical devices, the efficiency may be represented by a simple formula.* In such cases, if we neglect all losses due to friction, valve resistances, clearance, resistances in pipes and passages, and mechanical friction of motors and compressors, we should have the following values

Pressures—	2	4	6	8 atmos.	
Efficiency—	0.72	0.54	0.46	0.42	(1)

On the other hand, if the air should be used expansively, as it is in the best motors and, let us assume, without gain or loss of heat (that is, by adiabatic expansion); then the theoretical efficiency of the combined air compressor and air motor under such assumed perfect conditions would be given by a somewhat more complex formula.† Under such conditions the air would, of course, be greatly reduced in temperature towards the end of expansion and thus subject the motor exhaust ports and passages to the freezing-up process. These difficulties will be treated of presently. Adiabatic expansion is nearly realizable in practice. If now we neglect as before all subsidiary losses due to clearance, air resistances and mechanical friction of moving parts, we should have the following values from the formula (2) referred to:

Pressures–	2	4	6	8 atmos.	
Efficiency–	0.906	0.824	0.780	0.752	(2)

To obviate the "freezing up" of the air exhaust, all we shall have to do is to slightly heat the air before it is used in the motor. But this will be accompanied with a most marked improvement of the efficiency, not only from a thermodynamic standpoint, but from a thoroughly practical one as well. The air may be heated by coal or gas at no great expense on the one hand, and with very little additional trouble on the other. In point of fact, there is scarcely any other field of engineering in which the application of a given amount of heat from the combustion of fuel or gas will be accompanied by so radical and so attainable an increase in efficiency of the heat engine or other mechanism.

For street car work, probably the most efficient means of heating the air will be by means of a small gas furnace, which in winter would supply the necessary heat for the comfort of passengers as well. Heat energy has been satisfactorily stored in the so-called hot water systems of thermal storage, and this would prove equally beneficial for either of the above purposes. In stationary air motor plants, steam has been injected into the air motor cylinder to reheat the air, and with very satisfactory results.

The increase of efficiency of the combined air compressor and motor, due to reheating the air before its expansive use in the motor, will be represented by the ratio of the respective initial temperatures on the absolute scale; thus, if the air is heated to 360 degs. F., from a temperature of 60 degs. F., the following will be the ratio of increase of efficiency:

$$\frac{T}{t}=\frac{461+360}{461+60}=\frac{821}{521}=1.575. \quad (3)$$

If we apply this ratio to the values of the several efficiencies given for the combined air compressor and motor, in the case of adiabatic expansion, we shall have the following very satisfactory showing for the performance of the compressed air system:

Pressures—	2	4	6	8 atmos.	
Efficiency—	1.42	1.29	1.23	1.18	(3)

The range of efficiencies in the above instances running beyond that of 100 per cent. need cause us no concern when it is remembered that this increased efficiency is obtained by the expenditure of a definite amount of heat. This heat has been used to raise the temperature of the air from 60 degs. F. to 360 degs. F., our example chosen. The air, of course, is maintained at constant pressure during the heating, or nearly so. Therefore, the amount of heat required to raise one pound of air through this range can be easily calculated from the specific heat of air at constant pressure. While it is true that all of this heat is not later on returned in the form of mechanical energy, owing to radiation losses, inefficiency of the transmission of heat through the pipes or metallic surfaces of the reheater, etc.; yet it has been established by theory and experiment that a much larger return of energy is made in this case than in any other form in which heat energy is converted into work.

If we take the working pressure of six atmospheres of the street railway motor, we note the combined efficiency of compressor and motor to be 1.23; that is to say, neglecting all of the losses, due to air resistance and mechanical friction, etc., as we have indicated, and adding heat energy to the air in raising its temperature of 60 degs. F. to 360 degs. F., we are able to obtain, theoretically, 126 HP from the car motor for 100 HP expended in compressing the air at the central station.

Nothing has been said about the variation of the efficiency of the compression and expansion process with load. Experiments are yet wanting which will fully establish the character of such variations. But, the mechanical efficiency of the air compressor and air motor can be readily determined for any machine at the various loads and the curve of variation plotted. The losses in this case are entirely due to the friction of the mechanism and moving parts.

The following may be taken as an example of the actual realizable efficiencies, *at full load*:

Mechanical efficiency of two-stage air compressor, driven by steam engine	0.87
Efficiency of the two-stage air compression—partially-cooled compression with intercooler between air cylinders	0.90
Efficiency of the partially-heated expansion process, in air motor cylinder	0.85
Mechanical efficiency of air motor, as a converted steam-engine mechanism	0.90
Final efficiency of the compressor-motor combination, without reheating air before use in motor cylinder	0.60
With reheater, heating air from 60 degs. F. to 360 degs. F., before use in motor cylinder, thereby increasing output in ratio of 1.575	0.945

$$*\text{Efficiency} = \frac{1-\frac{P_a}{P_1}}{\log_e \frac{P_1}{P_a}} \quad \text{..................}(1)$$

where P_a and P_1 represent respectively the pressure of the atmosphere and the final pressure of compression for the air compressor; and for the air motor these same values would also represent the initial pressure of expansion which is of course assumed to be carried down to that of the atmosphere P_a

$$\dagger\text{Efficiency} = \frac{95{,}600\left[1-\left(\frac{P_a}{P_1}\right)^{0.29}\right]}{27{,}710\ \log_e \frac{P_1}{P_a}} \quad \text{..................}(2)$$

The relative increase of output, due to reheating, is shown in the curves of the three groups of efficiencies, as plotted in Fig. 3.

No other system of power transmission, and particularly for street railway work, is so admirably adapted to fulfill all the exacting requirements of such a field. Nor is it possible by any other system to so rehabilitate or restore energy to the working fluid after it leaves the generator and at such slight additional expense. In the cable system there are persistent and continuous losses from mechanical friction all the way from the engine to the cable car. In the electric system these losses are equally cumulative in amount and character.

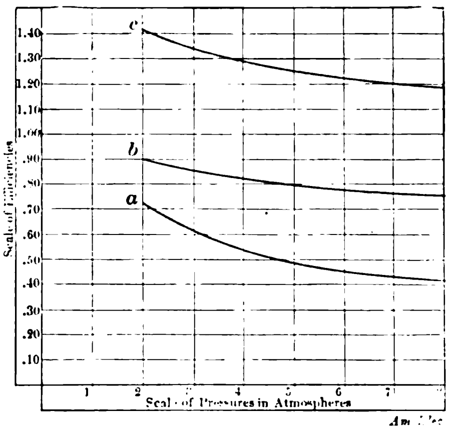


FIG. 3.—SHOWING VARIATION OF COMBINED EFFICIENCY OF AIR COMPRESSOR AND MOTOR, UNDER THREE SETS OF CONDITIONS OF USE.

(*a*) Isothermal compression and non-expansive working of air in motor.
(*b*) Isothermal compression and expansive working of air in motor.
(*c*) Isothermal compression and expansive working of air in motor, after it is reheated, from 60° to 360° F.

Within the short space of this article, it will not be possible to consider all the characteristics of compressed air working for this particular field. It is not to be presumed that the low pressure of six atmospheres would be used throughout such a commercial system. For, in transmitting compressed air to the several points of supply along the pipe lines laid down in the several streets, the efficiency of such pipe line transmission would be an important item and dependent upon the velocity of flow in particular. The case is somewhat different from that of a simple yet continuous transmission of power by compressed air; for the variation in the rate of flow would certainly be of an intermittent character—at times no air being drawn from the supply line. When charging the air reservoirs of the motor cars, the losses would be largely due to air friction, such in fact as are found in transferring air from one reservoir to another. In other words, the system of piping throughout the district of such a supply would be designed on quite different lines from that of the usual case of the transmission of power by compressed air. Such street railway supply piping would be unusually large and serve in fact as a reservoir for the storage of air. Even if otherwise designed, as for a simple case of transmission of power, the actual loss in pipe line transmission would be found to be exceedingly small.

The air at high pressure would be taken from street mains and stored in the reservoirs of the motor cars. It would then be drawn upon as required for the service of the road through the reducing valves and mechanism for regulating supply to the air motor under constant pressure. The problems involved in such regulating and reducing valves have been fully worked out in other lines of compressed air work and present no serious difficulty.

A combined system of street railway work seems more probable than entire dependence upon any one method of propulsion. The trolley system for suburban and outlying districts, transferring to a compressed air system for the crowded portions of the city, would appear to be more nearly ideal than combined trolley and cable systems. The pressure and capacity of the storage reservoirs of the motor cars can be so designed that no supply of air need be required at any point along the line. The cars would be supplied with compressed air at the generating station similar to the present method of the storage battery system. In the same central power plant would be gathered all the motive power machinery for the electric as well as the compressed air systems.

Compressed air may come to be the strongest ally of electric distribution rather than its avowed rival.

MEASURING THE INSULATION RESISTANCE OF HOUSE WIRING.

The following method of measuring the insulation resistance of house wiring is given by Dr. Oscar May in a German contemporary, one of the advantages claimed being that a battery is not required. The instrument used is a high resistance voltmeter or a milliamperemeter with a resistance in series with it, and in the method here described the latter instrument is used.

With a milliamperemeter having a resistance of one ohm, by means of shunts of $\frac{1}{9}$, $\frac{1}{99}$, $\frac{1}{999}$ or $\frac{1}{3999}$ ohm resistance, currents of 1.5, 15, 150 or 600 amperes can be measured; and by using resistances of 9, 99, 999 and 3999 ohms in series with the instrument, potential differences of 1.5, 15, 150 or 600 volts can be measured. The resistance of the instrument can, of course, be other than 1 ohm, and shunts and series resistances of any desired value may be used.

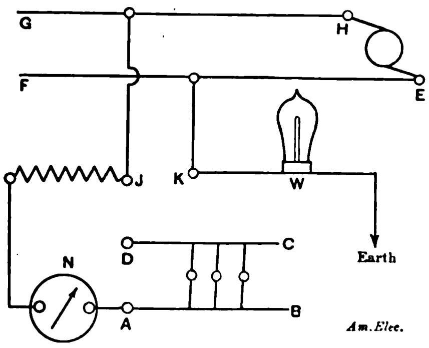


DIAGRAM OF CONNECTIONS.

To measure the insulation resistance of an installation, *A B C D*, the main fuses, *A J* and *K D*, are removed and the connections made as indicated. *R* is a resistance of about 1000 ohms, and *N*, is a milliamperemeter connected in series in place of the fuse, *J A*. The other main is connected at *K* to earth through a lamp, *W*. A few lamps are switched on the house circuit, *A B C D*, and the reading of the milliamperemeter noted, which we will call *A*. Then if *V* is the voltage between the mains, $\frac{1000 V}{A} - R$ is the insulation resistance of the installation.

THE NIAGARA-BUFFALO ELECTRICAL TRANSMISSION.

The Niagara-Buffalo transmission was inaugurated on Nov. 16, one minute after midnight with unqualified success, and electrical power from Niagara is now used to propel the electric cars of a number of important lines in Buffalo, the amount used being 1000 HP.

The transmission line is 26 miles long and passes over a private way. It is carried on shaved cedar poles painted white, ranging in height from 35 to 60 ft., according to the locality, and from 60 to 75 ft. apart. The poles are set 6 to 8 ft. deep, some simply placed in the clayey ground and tamped, while others, in moist and soft earth, are set in concrete. The pole line was erected by the White-Crosby Company.

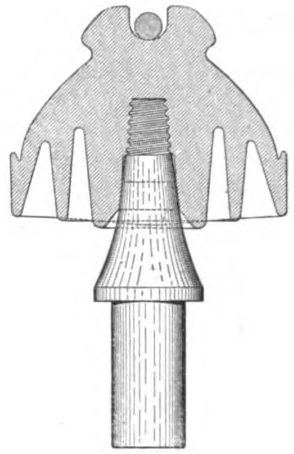


FIG. 1.—SECTION OF PORCELAIN INSULATOR.

Each single pole carries three cross arms, the upper two for the transmission wires, and the lowest for a telephone circuit. The transmission cross arms are of yellow pine, 12 ft. long × 4¾ ins. × 5¾ ins. Each arm will carry six insulators, three on each side of the pole, but three only are now in place screwed to wooden pins. On the outer end of each upper arm are two 18-in. iron pins on which is strung a galvanized barbed iron wire, which, grounded every fifth pole, serves as a lightning arrester.

The line consists of three conductors of bare copper, of 350,000 cm. cross-section, each conductor being a nineteen-strand cable. Complete transposition of the wires is effected every five miles. These conductors are strung on porcelain insulators of heavy pattern, made by the Imperial Porcelain Works, Trenton, N. J. These insulators, one of which is illustrated in Fig. 1, have the appearance of large inverted soup bowls, with a cap having a longitudinal groove and two wings and a special dripway on the upper surface. Beneath they have two deep annular grooves, to prevent any moisture connecting the outside of the insulator and the supporting pin and thus cause a ground. Each insulator weighs about

12 lbs., and before acceptance was subjected to a test of 40,000 volts alternating. Failure in the smallest degree insured rejection. The conductors lie in the longitudinal grooves and are tied to the wings.

The total length of the line is 26 miles, and as the three-phased system demands the use of three circuits, the total length of conductor is 78 miles, the cable for each mile weighing about 5200 lbs. With a transmission of 1000 HP at 10,000 volts, the total drop is less than 3 per cent., the line being designed for 5000 HP.

The last 4200 ft. of the line is underground through a subway consisting of twelve ducts of vitrified tile laid in four layers of three each, each duct having a diameter of 3 ins. in the clear. The twelve ducts are surrounded on all sides with 4 ins. of concrete as a protection, and the top of the concrete is 18 ins. below the surface. This conduit is laid along the canal bank, and has sixteen manholes.

The overhead line from Niagara dips to a terminal house and is connected through lightning arresters to the underground cable, which runs along a short tunnel connecting the terminal house with the first manhole of the conduit.

The underground cable was supplied by the Safety Insulated Wire Company, and is insulated with $\frac{9}{32}$ in. thickness of rubber, then braided and sheathed with a heavy lead armor. This cable was tested to 40,000 volts for acceptance, and to 30,000 volts for experiment. It is said to have withstood the latter test without revealing weakness in the insulation. The conduit continues as far as the transformer house—a small one-roomed brick structure, built in the rear of the Niagara Street power house of the Buffalo City Railway Company.

The two-phased currents from the great 5000-HP generators revolving in the power house at Niagara, passes at a voltage of 2200 to the main switchboard. That portion intended for Buffalo is led in lead-covered cables over the bridge across the canal, where the cables are connected to the two-phased low-potential switchboard. From this they descend into an air-tight chamber in which are built the transformer supports. In this room, large enough for a man to move about in comfortably, all connections between the low-tension two-phased lines and the step-up transformer wires are made, the cables being supported by large porcelain insulators on iron brackets.

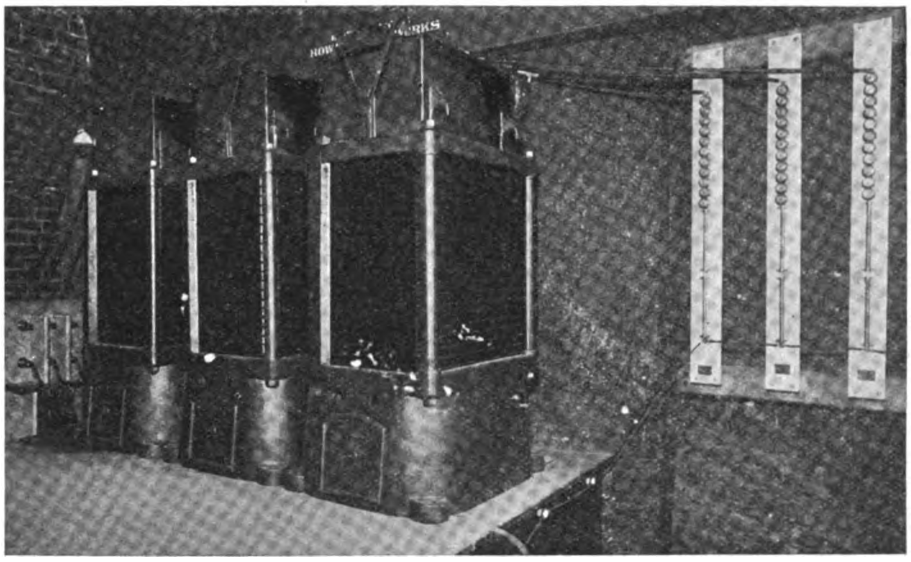


FIG. 2.—STEP-DOWN TRANSFORMER STATION—BUFFALO.

The "step-up" transformers now in position (Fig. 3) number two, and are rated at 936 KW each. They represent the latest practice in transformer design, are the largest yet constructed, and of the air blast type. Into the air-tight chamber beneath the transformers air is forced by a 60-in. blower, driven by a 5-HP multipolar direct-current motor. The coils of the transformers are arranged with the major axes in a vertical plane, and two main passages are provided—one through the iron of the core, and the other through the spaces between the coils. Through the open cast iron pedestals on which the transformers stand a blast of cool air passes directly into the main air passages and thence into a number of minor air ducts in the transformer. The admission of the air is regulated by dampers, which may be adjusted independently either for the coils or the core.

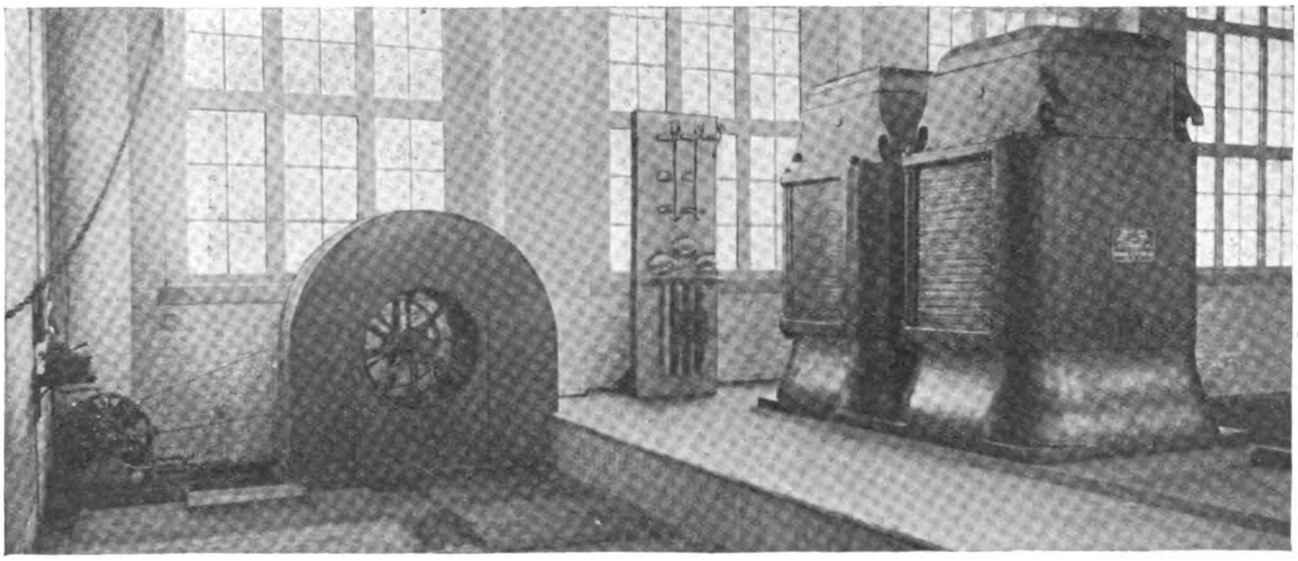


FIG. 3.—STEP-UP TRANSFORMER STATION—NIAGARA.

The step-up transformers are 94 ins. high, and each weighs 25,000 lbs. They raise the voltage from 2200 volts to 11,000 at present, but are designed to allow of a voltage of 22,000 by a change in the connections. They stand on frustrums of rectangular pyramids mounted on an iron framework and are encased in suitable iron frames, the frame being provided on the top with cast lugs by which they may be readily handled with the traveling crane which runs along the roof of the transformer house.

It is in these transformers that the two-phased system is abandoned. From them three currents issue differing in phase by 120 degs. The connections are brought out at the bottom, and continue to the high tension marble switchboard for connection to the transmission lines. The equipment of this board is of special design to permit of the handling of the high voltage current without danger. Each conductor from the transformer is connected to a single-pole switch of quick-break type, mounted on heavy insulating pedestals, and separated from its neighbor by a barrier of marble much higher than the closed switch and about one inch thick. These three switches control the output of any two of the 935-KW step-up transformers which may be connected for either 11,000 or 22,000 volts. Each conductor has its fuse carrier of special type designed for this transmission. Each carrier is twenty-four inches long and is forced into contacts mounted, like the switches, on large insulating pedestals. Each has two handles, and the construction is such that they can be removed from the board for the insertion of new fuses without danger. The high tension switchboard also carries current indicators and voltmeters. From this switchboard the conductors pass to a small extension building where they are connected through lightning arresters to the overhead wires leading to Buffalo.

The transformation of the current at the Buffalo end of the line is effected in three "step-down" transformers (Fig. 2), constructed similarly to those used to step-up the pressure, and cooled by the same process, the centrifugal blower being driven by a 2-HP motor. The line enters the small building outside the railway company's power house, from the underground conduit, through lightning arresters and is connected to the high tension switchboard, which is a duplicate of that in the transformer house at Niagara. From the switchboard the conductors are brought into the transformers from the top, and the three currents issue at about 370 volts pressure.

Three of the four step-down transformers are set up. Each is 32 ins. high and weighs 7000 lbs. The currents are turned into them at 10,700 volts or 21,400 volts pressure, and issue at the pressure just mentioned.

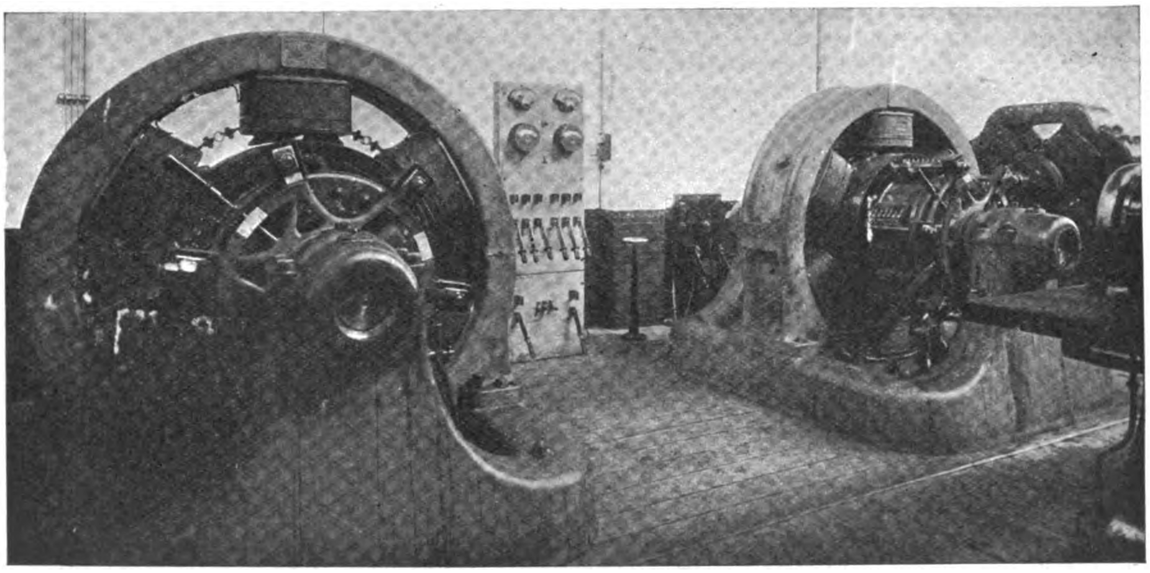


FIG. 4.—DIRECT-CURRENT TRANSFORMERS AT BUFFALO STATION.

From the transformers six cables—that is, three for each three-phased circuit—are carried through the wall of the step-down transformer house up to the main floor of the railway power station above. Here they are connected to the switchboard equipped with six knife-blade switches, one for each cable, ammeters, etc., a field switch and two switches connecting to the main bus bars of the railway switchboard. From the board the two three-phased circuits run to two rotary converters (Fig. 4), each of 500 HP capacity. These converters are six-pole machines and by their operation the three-phased, 370-volt, alternating currents are changed into a direct or continuous current at a voltage of 500 for connection to the feeder lines of the railway company. The armature of the converter is fitted with three alternator collector rings on the side nearest the switchboard, while the other carries a commutator similar to that of the ordinary direct-current dynamo. The three-phased currents are brought to the brushes and enter the armature. As soon as the necessary speed is reached, as indicated by the voltmeter, the main switch on the board is closed and the direct current passes from the commutator brushes to the main buses of the railway switchboard. The converters may also be started by direct current taken from the lines, and the direct current from them can be thrown either to the board for operation in parallel with the generators now in operation in the power house, or directly to the feeders.

The lightning arresters of the Wurts type have been especially designed for heavy voltage transmission work and are single-pole. They consist of a strip of marble upon which are mounted eleven cylinders, giving one air gap space $\frac{1}{32}$ in. for each 1000 volts, with an allowance of 25 per cent. rise in the potential. In the action of the arrester the large metal cylinders serve to chill the arc, so that on reversal of the current the arc is extinguished, no dependence being placed upon any non-arcing property of the metal to put out the arc. In order to limit the current on short circuit, and thus the heating effect, a special solid graphite rod of low non-inductive resistance is used. The arresters are similar to those used on the Big Cottonwood transmission at Salt Lake City, which have effectually protected the machinery in many severe storms, and are now being used extensively in transmissions where high voltages are employed.

The carrying capacity of the present three-phased circuits at 11,000 volts, is 5000 HP; at 22,000 volts, with a smaller drop, 10,000 HP. The capacity of the pole line, therefore, is 40,000 HP at the higher voltage.

At Niagara Falls an extension of the power house equipment is already under way. The output of the present 5000 HP generators, three of which are in constant operation, is already taken and distributed to the factories of the Carborundum Company, the Calcium Carbide Company, the Niagara Falls Paper Company, the Pittsburgh Reduction Company, the Niagara Falls Chemical Company, to the Niagara Falls & Buffalo Railway, a line of electric cars running between the two cities, and other lines in Niagara. Another wheel pit, of similar depth to that already in use, is being excavated as a continuation. It will be three times as long, or 430 ft. × 20 ft. and will contain, when equipped, seven additional turbines with penstocks and turbine shafts. Seven additional 5000-HP generators will be operated by these turbines, and the complete plant will have a total output at full load of 50,000 HP.

FRICTION AND LUBRICATING OILS.

BY C. A. COLLETT, V. P., N. A. S. E.

Friction as been defined as: "The resistance occasioned to the motion of a body, when pressed upon the surface of another body which does not partake of its motion." This is called sliding friction, in contradistinction to rolling friction, as when a body revolves upon rollers which themselves revolve upon their own bearings, or when a body rolls upon a smooth plane. General Morin, who spent considerable time, money and research in his experiments on friction, and who was, no doubt, fully competent to make them, is generally credited with the original discovery of the following laws of friction:

1st. The friction bears to the pressure on the surfaces in contact a ratio which is constant for the same materials, and with the same condition of surfaces.

2d. The measure of the friction is independent of the extent of the surfaces in contact, the pressure and the condition and character of the surfaces remaining the same.

3d. The friction is entirely independent of the velocity of continuous motion.

There are many persons who believe in the truth of the first and second laws above given, yet who do not believe that an engine would turn as easily if the face of its twenty-foot flywheel were made use of as a journal for the crankshaft, as it would if that journal were on the shaft itself, and only twenty inches in diameter. And this is entirely consistent, because, although the resistance to motion would be exactly the same in each case, provided the character and condition of the surfaces were the same, yet in one case that resistance would be applied at the end of a lever ten feet long, and in the other case it would be applied at the end of a lever only ten inches long, which would make the engine work just twelve times as hard to overcome it. We may increase the surface of a journal by adding to its length as much as we please, without increasing the friction or the power necessary to overcome it. Neither will we increase the *friction* by adding to the diameter of the journal, but we must certainly increase the power to overcome it.

The first and second laws have been repeatedly proven to be true by actual experience; and they are dependent upon one another. If one is disproved it is evident that the other is disproved also. Anyone, by taking a block of cast-iron or any convenient material, having any number of faces of different areas, and by means of weights dragging it along over a surface, first sliding it on one face and then on another of different size, can satisfy himself that friction is really independent of the extent of surfaces in contact. And by piling other weights on top of the first one he can demonstrate the truth of the first law also. But he must in all cases have the weights move at the same speeds as the blocks, or, in other words, have no leverage.

Now in regard to the third law, it is held by some persons that it is not true, because journals that heat at high speeds, run perfectly cool at less velocities. But, upon reflection and investigation this is not inconsistent with the third law at all. It is held, that if two surfaces could be produced which were *perfectly smooth*, and so hard as to be entirely unyielding, there would be absolutely no friction between them when placed together. M. Poirée says: "Though constancy of friction holds good for velocities not exceeding 15 or 16 ft. per second, yet, for greater velocities, resistance of friction appears to be diminished in the same proportion as velocity is increased."

We gather from this, that, under certain conditions and with favorable environments, the velocity might be increased to such an extent as to completely annihilate friction. Friction is believed to be caused by the more or less minute projections and cavities on the surfaces of metals in contact, and that these projections interlock, and require force to separate them. This force, in accordance with a universal law, manifests itself in the form of heat. If the motion was slow, say, one revolution per minute, there would be a certain amount of heat developed, but it might be so small as to be absorbed by the parts of the machine itself and the atmosphere. But now suppose the speed to be increased to five thousand revolutions per minute, it would require the same force per revolution, and there would consequently be the same amount of heat developed per revolution; but there would evidently be five thousand times as much heat developed per minute as before, and this might be developing heat faster than it could be absorbed, in which case it would remain in the journal and cause trouble. So that, it is not a question of limitation of speed, so much as getting rid of the heat developed.

Morin's third law, however, is not believed to hold true under all conditions, as it is pretty well established that in extreme cases, such as very high or very low speeds, or very heavy or very light pressures, the coefficient of friction does not remain precisely the same. We have seen that two surfaces sliding one upon the other, being perfectly smooth and so hard as to be entirely unyielding, would produce no friction, and consequently would require no lubricant. But, since such conditions, while possible, are never met with in practice, lubrication of some sort must be resorted to in order to prevent the surfaces from heating.

The lubricants for machinery in most common use are animal and mineral oils, and these are graded to meet all manner of requirements. It is a pretty generally accepted proposition that the quality of an oil usually improves as the price increases, but it would be a positive error to use an oil whose increased useful effect would be insufficient to justify the greater cost. On the other hand, it would be just as false economy to use an oil of half the cost, if it required more than twice the quantity to produce the same effect. But, the price of an oil is not always a measure of its quality; because, while one dealer may succeed in selling a prime grade of, say, cylinder oil, at one dollar per gallon, another dealer, satisfied with a closer margin of profit, may offer an oil equally as good, at seventy-five cents per gallon. It is safe to assert that not one consumer in fifty is a competent judge of the quality of the oil he buys; much less does he know anything about its component parts, for with the exception of sperm and lard oils, all other lubricating oils are compounded.

For example, mineral cylinder oil is usually composed of cylinder stock and paraffine oil, while a cheaper grade includes also neutral oil and mineral gelatine. A "heavy body"—so called—is not always indicative of the best lubricant, because a body may be given to neutral oil, for example, by simply mixing it with mineral, or with animal gelatine. Now, the galatine in this compound has very little of true lubricating qualities in itself, while the neutral oil has none whatever, but mixed together, they produce an oil with a heavy body, so tempting and alluring to the average buyer of lubricating oils.

It is a fact also, and it is well to bear it in mind, that an oil possessing all the essentials and characteristics of a good lubricant may have too much body for the bearing to which it is to be applied, so much so, indeed, as to cause a resistance to the power driving the shaft. If we examine, under a microscope, a shaft journal which is perfectly cylindrical and smooth, we will find the surface apparently quite rough, and covered with indentations, grooves and ruts. These afford lodging places for the oil, for otherwise the bearing could not be kept cool through the agency of the oil, since a film of oil must always be present and intervene between the journal and its bearing. Thus we see that only sufficient body in an oil is required to keep it from running off the journal, as pure water would whether the journal was revolving or at rest. Any more body than this would be a positive detriment in so far as causing a resistance to the power driving the shaft.

In a succeeding article the various kinds of lubricating oils will be taken up and discussed in detail.

MAGNETIC HYSTERESIS.

BY ERNEST J. BERG.

A current passing through a conductor represents a magnetomotive force (M. M. F.) which, acting on any medium, produces a flux of lines of force. This flux in non-magnetic materials such as air, varies directly with and is proportional to the M. M. F., but in any magnetic material, such as iron, nickel, etc., it is larger than the flux produced by the same M. M. F. in non-magnetic material.

In magnetic material the flux at first increases very rapidly with smaller M. M. Fs.; then at a rate proportional to the M. M. F., as in air; and finally, when the iron approaches saturation, the rate of increase becomes smaller than the rate of increase of the M. M. F.

Reducing the M. M. F., causes a reduction in the magnetism, but this reduction is not proportional to the values obtained when the M. M. F. is increasing in strength, but to values which are higher. Consequently, when reducing the M. M. Fs., the corresponding values of the magnetism are always higher than those obtained when raising the M. M. F., so that when the M. M. F. has been reduced to zero, there still remains a certain magnetism called the remanent magnetism.

This lagging behind of the magnetism relative to the M. M. F. is denoted hysteresis. The amount of this lag depends upon the metal and upon its physical condition; for instance, with soft iron it is less than when the iron is hardened.

The loss in power due to hysteresis is caused by the friction between the molecules in being magnetized; or we may say that when the iron molecules are being magnetized, they have to be arranged in a certain way different from that in which they were before the magnetization. In magnetizing iron, the work of changing the position of the molecules is represented by molecular friction, which is the same as hysteresis if no outside power is supplied to the magnetic material; if, however, outside power, such as heat or mechanical vibrations, is acting upon the iron, it is greater than the hysteresis. It is thus evident that the hysteresis loss will be less in a dynamo which has a revolving magnetic circuit than in stationary electrical apparatus, such as transformers, for the same frequency and the same magnetization.

This loss due to molecular friction, which in most cases is represented solely in the hysteresis loss, is proportional to the 1.6 power of the magnetization, and directly proportional to the number of reversals of magnetism per unit time—that is, to the frequency.

It is of practical interest to see how this loss depends upon the voltage, frequency, etc., of any type of alternating current machinery. We will, therefore, discuss the following practical cases, assuming the case of a stationary transformer:

First, the effect of changing the impressed E. M. F. at constant frequency.

Since the magnetism is proportional to the E. M. F. we have, if

W = watts loss at frequency n and voltage E

W_1=watts loss at frequency n_1 and voltage E_1

$\mathfrak{B}$ =magnetic density at frequency n and voltage E

$\mathfrak{B}_1$ =magnetic density at frequency n and voltage E_1

$$\frac{W}{W_1}=\frac{\mathfrak{B}^{1\cdot6}}{\mathfrak{B}_1^{1\cdot6}}; \text{ but } \frac{\mathfrak{B}}{\mathfrak{B}_1}=\frac{E}{E_1}; \text{ therefore}$$

$$\frac{W}{W^1}=\frac{E^{1\cdot6}}{E_1^{1\cdot6}} \text{ or } W=W_1\times\left(\frac{E}{E_1}\right)^{1\cdot6}$$

or the loss is proportional to the 1.6 power of the impressed E. M. F.

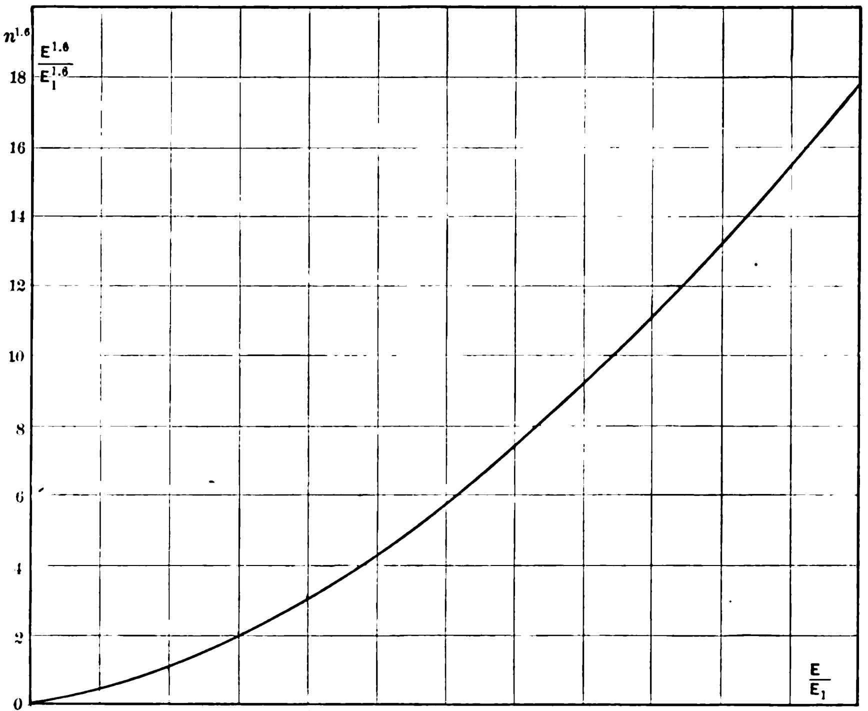


FIG. 1.—CURVE OF 1.6 POWER.

In Fig. 1 is given a curve of the 1.6 power which will enable us to get directly the loss at any ratio between E and E_1; thus, for instance, if the hysteresis loss at 1000 volts is W_1, what is the loss if the same transformer is used on a 2000 volt circuit? We have

W = unknown
W_1 = known
E = 2000
E_1 = 1000

and $\frac{E}{E_1}=\frac{2000}{1000}=2$

From the curve we find that $\left(\frac{E}{E_1}\right)^{1\cdot6}=3$, that is, $W=3\ W_1$, or the loss is three times as large; consequently, the heating of the transformer on account of the hysteresis loss (which is about ½ of the total loss) will be three times as large.

Second. The effect of changing the frequency of a system on transformers operated at the same voltage as before.

For a constant impressed E. M. F. the magnetism, $\mathfrak{B}$, varies inversely as the frequency. Therefore

$$\frac{\mathfrak{B}}{\mathfrak{B}_1}=\frac{n_1}{n}, \text{ and } \frac{\mathfrak{B}^{1\cdot6}}{\mathfrak{B}_1^{1\cdot6}}=\frac{n_1^{1\cdot6}}{n^{1\cdot6}}.$$

The hysteresis loss is proportional to the frequency, and the 1.6 power of the magnetism $\mathfrak{B}_1$ or $\frac{W}{W_1}=\frac{n}{n_1}\ \frac{\mathfrak{B}}{\mathfrak{B}_1}$.

Therefore we get $\frac{W}{W_1}=\frac{n}{n_1}\times\frac{n_1^{1\cdot6}}{n^{1\cdot6}}=\frac{n_1^{\cdot6}}{n^{\cdot6}}$

$$\text{or } W=W_1\left(\frac{n_1}{n}\right)^{\cdot6}$$

In Fig. 2 is given a curve giving the ratio of $\left(\frac{n_1}{n}\right)^{\cdot6}$ for any ratio of $\frac{n_1}{n}$ If, for instance, the loss at 100 cycles is W_1, what is the loss at 50 cycles? We have then $n_1=100$, $n=50$, $\frac{n_1}{n}=\frac{100}{50}=2.$

From Fig. 2 we find that for the value of

$$\left(\frac{n_1}{n}\right)^{\cdot6}=2\ \left(\frac{n_1}{n}\right)^{\cdot6}=1.5; \text{ that is, } W=1.5\ W_6$$

or the loss is increased by about 50 per cent.

In these instances we have assumed the hysteresis loss at a certain voltage and frequency to be known.

In most cases it is very hard to calculate this loss, since, as stated above, it not only depends upon the magnetization of the iron, but also upon its physical condition. According to Steinmetz's law the hysteresis loss is expressed in equation $W=\eta\,\mathfrak{B}^{1\cdot6}$

where W = loss of energy per cycle in ergs. per cm^3

$\mathfrak{B}$ = maximum magnetic induction in lines of force per cm^2

η = coefficient of hysteresis.

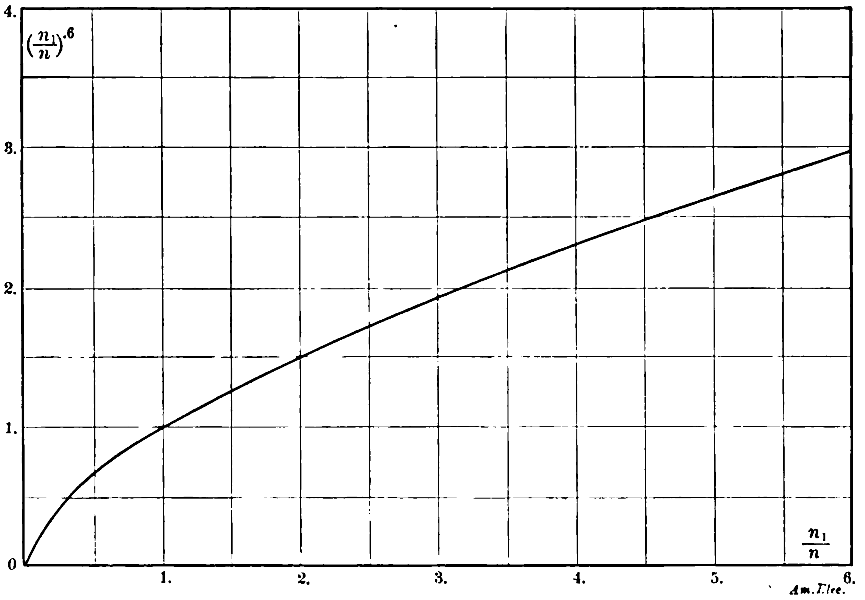


FIG. 2.—CURVE OF .6 POWER.

The value of this coefficient varies within very wide limits, being, for instance, .001 for exceedingly pure soft annealed sheet iron, and .080 for hardened steel. As an average value in transformer iron we may use $\eta=.003$.

The most accurate means of finding the loss, is, however, by experiment, and since the only instruments necessary for this are an ammeter, a voltmeter, and a wattmeter, a test of the hysteresis loss in any alternating current apparatus can be made in most any of our power stations. The connections for this test are given in Fig. 3.

G is an alternating current generator, *T*, a step-down transformer, *A* an ammeter in the low potential circuit, *V* a voltmeter at the terminal of a transformer *T*, which is to be tested, and *W* a wattmeter with the current coil in the low potential main and the potential coil across the terminals of transformer, T_1.

With the high potential winding of the transformer, T_1, open circuited, the wattmeter, *W*, registers the "core loss" of the transformer at the voltage indicated by *V*. The ammeter, *A*, gives the exciting current —that is, the current necessary to give the magnetization and the hysteresis loss.

We said above that the "core loss" was found for the transformer. This loss is, however, not the hysteresis loss alone, but includes also the loss of energy due to eddy or Foucault currents. To separate the eddy current losses from the hysteresis loss, we will have to make an analytical investigation.

As above stated, the hysteresis losses are proportional to 1.6 power of the E. M. F.; those of the eddy currents, however, are proportional to the square of the E. M. F. or $W_h=aE^{1\cdot6}$ and $W_e=bE^2$. These two equations give us the analytical means for separating the losses. Taking two values on different parts of the curve showing the total loss from eddy currents and hysteresis, and the corresponding voltage, and inserting two values in equations Watts $=W=aE^{1\cdot6}+bE^2$, and $W_1=aE_1^{1\cdot6}+bE_1^2$, we get the means of determining the constants *a* and *b*, and consequently can separate the hysteretic losses from the eddy losses.

The relative proportion between the losses due to eddy current and hysteresis can often be gotten with enough accuracy directly from the curve of the total core loss as follows:

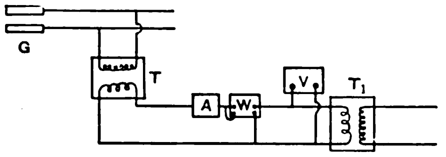


FIG. 3.—CONNECTIONS FOR CORE LOSS—TEST OF TRANSFORMERS.

If $a\ a_1$, (Fig. 4) represents the core loss at a certain voltage, and $b\ b_1$ the core loss at a voltage which is twice as high as that at $a\ a_1$, then if the length of ordinate $b\ b_1$ is three times that of $a\ a_1$, the losses are due to hysteresis; if four times, the losses are due to eddy currents. If between three and four times the losses are due partly to eddy currents and partly to hysteresis, being more largely due to eddy currents, if the ratio is nearer to four, or to hysteresis if the ratio is nearer to three.

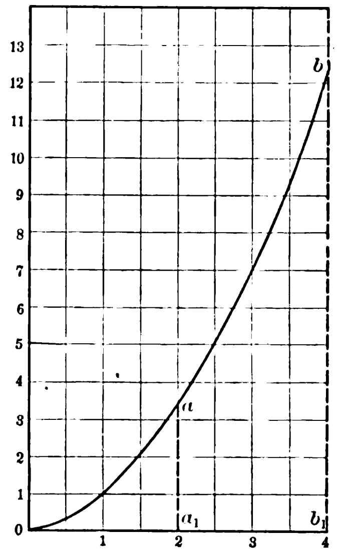


FIG. 4.—CURVE OF TOTAL CORE LOSS.

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ALTERNATING CURRENT TRANSFORMER ECONOMY.

In an introduction to Bulletin No. 11 of the University of Wisconsin, Prof. Dugald C. Jackson dwells upon the vital importance of transformer economy to central stations using alternating currents, and points out that the cheapest transformer is not always the most economical, and that individual tests of each transformer purchased are essential. The following are given by Prof. Jackson as guarantees which should be demanded by the purchaser of transformers:

1. Iron loss of transformer when operated on circuit at normal pressure never to exceed the values given in the table below for frequencies over 100 periods per second. (It may be advisable in some cases to accept a 10 per cent. higher loss for a frequency of 60, in order that the first cost of the transformer for this frequency need not be increased.)

2. Drop of secondary pressure due to loading the transformer not to exceed 3 per cent. between no load and full load.

3. Excess of temperature above that of surrounding air at full load after working ten hours not to exceed 70 degs. F. (nearly 40 degs. C.).

4. Disruptive strength of insulation between coils and between primary coil and iron, when heated by ten hours' run, to be at least ten times the primary pressure. Insulation resistance, when heated as above, to be not less than ten megohms and guaranteed not to deteriorate with reasonable service.

5. Exciting currents for 1000-volt transformers not to exceed values given in table when the frequency is above 100. If the frequency is less, the exciting current may be expected to increase as the frequency decreases. In transformers intended for other pressures than 1000 volts, the exciting current may be expected to vary inversely as the pressure. Consequently, if the exciting current of a 1000-volt transformer is tested by connecting its low pressure coil to the 100-volt lighting circuits, the amperemeter reading may be expected to be ten times as great as the value given in the table.

CAPACITY.	IRON LOSS.	EXCITING CURRENT.
1,000 watts..........	30 watts..........	.055 amperes.
1,500 watts..........	40 watts..........	
2,000 watts..........	30 watts..........	.080 amperes.
2,500 watts..........	60 watts..........	
4,000 watts..........	80 watts..........	
6,500 watts..........	100 watts..........	.100 amperes.
17,500 watts..........	150 watts..........	.200 amperes.

For intermediate capacities, intermediate values of the iron loss and exciting current may be expected.

The guarantees outlined may be easily met by any transformer manufacturer who builds safe and economical transformers, and they are now more than met by the transformers of a number of makers. Transformers which do not meet the insulation and heating guarantees are unsafe to use upon commercial electric lighting or motor circuits, while those which do not meet the iron loss, regulation, and exciting current guarantees waste the company's money. Transformers which entirely fulfill the economy requirements here given, when operated on a frequency of 125 or thereabouts, usually serve satisfactorily at a frequency of 60, so that it is not of patent advantage to buy more expensive transformers for the latter frequency.

In this connection Prof. Jackson calls the special attention of the owners and superintendents of central stations using alternating currents to the supreme importance of testing their transformers which are now on the line. Many of these transformers are of old styles and are wasting so much power that a considerable balance of profit may be shown at the end of a year if the wasteful transformers are "scrapped," or are traded with manufacturers for modern ones. Others amongst the old transformers are positively unsafe, and for self protection central station men should seek out and remove such transformers without an unnecessary day's delay. A high-pressure test is the only one which will satisfactorily demonstrate the safety of a transformer. The several tests recommended by Prof. Jackson for determining iron and copper losses, etc., will be found in the August number of the AMERICAN ELECTRICIAN.

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A METHOD FOR MEASURING RESISTANCE.

BY H. BEINHORN.

The methods usually employed for measuring resistance are based upon two different principles: 1. The disappearance of the effect of a current upon a magnetic needle (differential galvanometer). 2. The disappearance of a current in a derived circuit (Wheatstone bridge).

The following method is based upon still another principle, depending upon the value of the current becoming a maximum or minimum when the resistance is changed according to a certain law. The method will first be developed in its simplest form, its practical application being given afterwards.

Referring to Fig. 1, a current, *C*, produced by a battery, *E*, is divided into two parts, one flowing through the circuit containing the resistances, *a* and *r*, and the other through the circuit containing the resistances, *b*, and *s*, *a* and *b* being the two parts of a rheocorde or resistance wire. It is evident that when the contact, *M*, is moved along the resistance wire, the sum of the resistances, *a*, *r*, *b* and *s*, will remain the same, but that the value of the current, *C*, will change. If, for instance, *r* and *s* have nearly the same value, we should see, by the galvanometer, *G*, that in moving the contact from *A* to *B*, the current, *C*, will decrease, then increase, and therefore will have a minimum value when the contact is made at a certain point which, in the case of Fig. 1, we will suppose to be *M*. It can very easily be deduced that for this point, *M*, the resistances of the two branches are equal; that is, $r + a$ would equal $s + b$, or $s = r + a - b$. In order to measure an unknown resistance, *s*, we can therefore employ the following method:

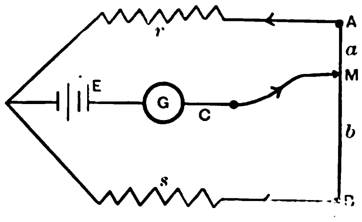


FIG. 1.—FIRST METHOD.

Move the contact, *M*, until the galvanometer shows the smallest current; then the resistance, *s*, must equal $r + a - b$.

Now it is obvious, that the strongest current will pass when *r* or *s* is zero, and a comparison of the expressions for the value of the maximum and minimum currents shows that, since the value of the resistance of the galvanometer circuit will naturally be great, the particular method just described is only applicable when the resistance, *s*, to be measured is large.

A second method is shown in Fig. 2, in which the current, *C*, is divided, after leading it through a resistance, *R*, into three branches, c, c_0 and c_2, the resistances of which are respectively *r*, *G* and *s*. It can again be easily shown that *C* will be a maximum when *r* is equal to *s*, or when $s + b = r + a$. Thus we have another method for measuring an unknown resistance, *s*, as follows:

Move the contact, *M* (Fig. 2), until the galvanometer shows the strongest current; then we know that $s = r + a - b$. By consideration of the expression for the value of the resulting currents, it may be seen that to make the method as adaptable as possible, we have to choose *R* and *G* as small as possible. It, therefore, depends upon the sensitiveness of the galvanometer used how small a resistance can be measured by this method.

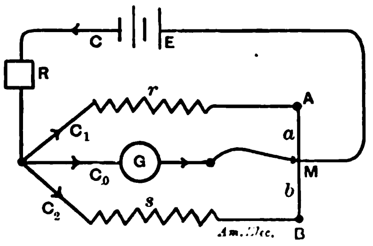


FIG. 2.—SECOND METHOD.

Both the methods above described have the disadvantage that the minimum or maximum of *C* is difficult to exactly observe. From Fig. 3, in which the vertical lines of the symmetrical maximum and minimum curves there shown represent current values, c and c_0, and the horrizontal lines represent resistances, $r + a$, it will be seen that for each value of current there are two values of resistance. Therefore, we can also apply the method in the following manner:

After having observed that the minimum or maximum of *C* will approximately correspond to a point, *M* (Fig. 4), lying nearer to *A* than to *B*, move the contact to a point *A′*, yet nearer to *A* than to *M;* then move, observing the deflection of the needle, the contact in the direction, *B*, to a point, *B′*, such that we get the same deflection of the needle as before. Suppose the resistances of *AA′* and *BB′* to be *a′* and *b′;* then $s = r + a' - b'$. A commutator, as indicated in Fig. 5, will assist this operation.

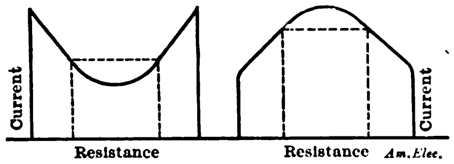


FIG. 3.—MAXIMUM AND MINIMUM CURVES.

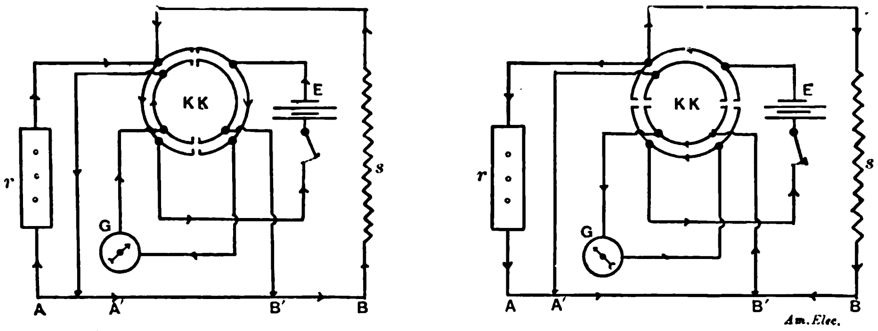


FIG. 6.—FIRST METHOD WITH ROTARY COMMUTATOR.

Still, however, this method has yet a great disadvantage; it assumes that the E. M. F. of the battery and its internal resistance are constant, which seldom will be the case.

To make ourselves independent of the battery and to finally place the method on a practical basis, we will introduce a rotary double commutator, *KK* (Figs. 6 and 7), instead of the single commutator, *K* (Fig. 5), so that the direction of the current is reversed at the moment when the contact, *A′*, is exchanged with the contact, *B′* (Fig. 4).

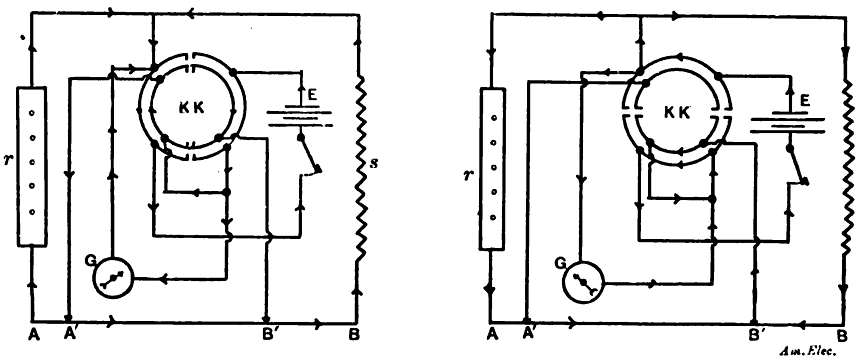


FIG. 7.—SECOND METHOD WITH ROTARY COMMUTATOR.

Then the needle of the galvanometer will move in opposite directions and the commutator being turned quickly, there will be a tendency toward an oscillating movement, the middle of which will be a point of repose.

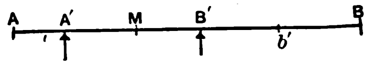


FIG. 4.—RHEOCORDE CONTACTS.

The application of this final method is, therefore, as follows: Making sure that the difference of the resistances, *r* and *s*, is small, so that the point, *M*, can be found by moving the contact along the rheocorde, and having selected a point, *A′*, for the first contact, move the second contact to a point, *B′*, so that the center of the oscillations of the needle, produced by the turning of the commutator, *KK*, will be the point of its repose; this will indicate that $s = r + a' - b'$. Then check this point by turning the commutator slowly and observe if the needle will be deflected equally to both sides; the latter will prove whether the observation is exact or not. Figs. 6 and 7 show how to apply the commutator, *KK*, and give the connections for this final and practical method.

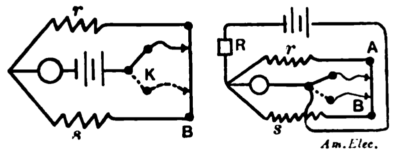


FIG. 5.—FIRST AND SECOND METHOD WITH SINGLE COMMUTATOR.

To determine the value of $a' - b'$, it is sufficient to know the resistance of $a + b$ of the whole rheocorde, and to observe the lengths, *AA′* and *BB′*, the wire of the rheocorde being supposed to have the same cross-section at every point. To avoid errors when this condition is not fulfilled, it will be well to take several readings for different positions of the contacts, *A′* and *B′*.

The advantages of the last method described are independence of the battery, independence of the kind of galvanometer used and exactness of the observations entering into the formula.

◆

CALCULATION OF A THREE-PHASED TRANSMISSION LINE.

In the calculation of a three-phased transmission line three factors enter—ohmic resistance, power factor and reactive drop. The second of these depends upon the inductance of the receiving apparatus, which causes the current of the line to be increased over that necessary if, for example, incandescent lamps (which are practically non-inductive) were alone in circuit. This extra current involves only an expenditure of power to compensate for the C^2R loss in the transmission line, and may be allowed for by adding the necessary amount to the amperes to be transmitted, before calculating the line.

The resistance drop is due to the lines of force of the current transmitted cutting in and out of the loops formed by the transmission line, thus generating a back E. M. F., as in a "choking" coil. Since the amount of this drop depends upon the size of the line wire used, the distance apart of the several wires, the manner in which they are arranged with relation to each other, and upon the electrical capacity of the system, its calculation depends upon the data of each particular case. It is quite probable, however, that in practice the reactance drop will be nullified by the use on the line of overexcited synchronous motors, thus enabling the calculation of a three-phased transmission line to be made on the basis of simple ohmic resistance.

It can be shown that, on the basis of effective voltage, a three-phased line only requires 75 per cent. of the copper needed for a simple alternating or direct current line to transmit the same power at the same loss. Suppose that the cross-sectional area of each of the wires of the latter lines is represented by 2; then the area of the two wires is 4. Since there is a saving in the three-phased system of 25 per cent., the corresponding cross-sectional area for that system would only be 3, and since there are three wires, the area of each would be 1. In other words, on the assumption above made, *the cross-sectional area of each wire of a three-phased line is half that of each wire of a line calculated to carry a simple alternating or direct current.*

As an example, suppose 1000 HP at the generator terminals are to be transmitted 30 miles at 11,000 volts and with a line loss of 5 per cent.—power factor and line reactance being neglected.

1000 HP = 746,000 watts (C E). Dividing the watts by the voltage (E) we have the amperes, or 67.8. The drop in volts is .05 × 11,000 = 550. The resistance of the line is the drop divided by the current,

$$\left(R = \frac{E}{C} \right) \text{ or } 8.11 \text{ ohms.}$$

There being 60 miles in the circuit, the resistance per mile of the wire is .135 ohm. By reference to a wire table, or from the formula,

$$\text{circular mils} = \frac{10.5 \times \text{feet}}{R},$$

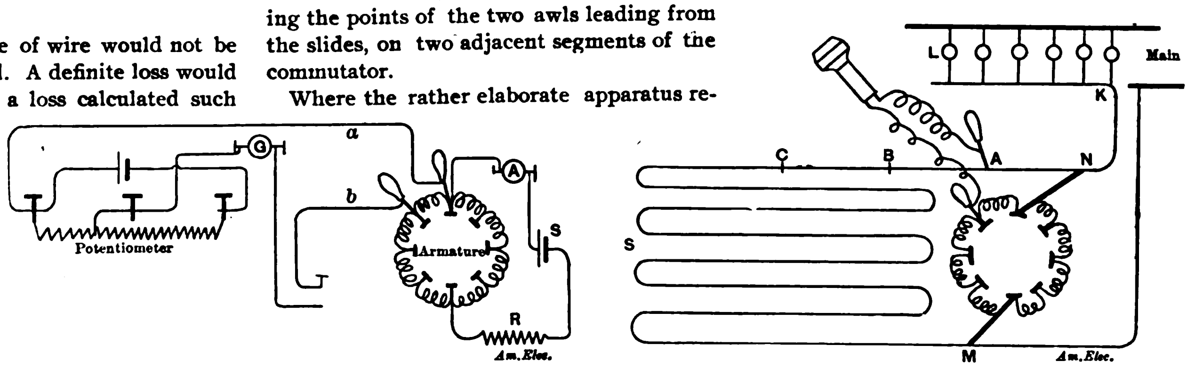
we find that this corresponds to 410,000 cm, about. For the two wires this will be 820,000 cm. Three-fourths of this is 615,000 cm, and one-third of this is 205,000 cm, which is the size of each of the three-phased wires, or somewhat less than No. 0000, B. & S.

Practically, the size of wire would not be so simply determined. A definite loss would not be assumed, but a loss calculated such that the annual interest on the cost of the line would equal the annual cost of the electrical energy dissipated by the resistance of the line, this statement being known as Kelvin's law.

As an illustration of the converse of the above method, let us determine the drop over a three-phased line, transmitting 5000 HP from the generator terminal at 11,000 volts over twenty-six miles, each conductor having an area of 350,000 cm. This approximates to the case of the Niagara-Buffalo transmission.

The combined cross-sectional area of the conductors is 1,050,000 cm; this being 75 per cent. of the area of a direct current two-conductor line for the same loss, the combined cross section of the conductors of the latter will be 1,400,000 cm, or 700,000 cm for a single conductor. As the length of the line is 26 miles, there will be 52 miles of conductor, and by reference to a wiring table or by calculation from the formula, $R = \frac{10.5 \times \text{ft.}}{\text{circ. mils}}$, we find the resistance to be 4.12 ohms.

Finally, 5000 HP are equivalent to 5000 × 746 = 3,730,000 watts (C E); the current, therefore, is that quantity divided by the voltage, (11,000), or 339 amperes. Therefore, the drop, being the product of the resistance by the current, is 412 × 339 = 1396 volts, or 12.7 per cent.



FIGS. 1 AND 2.—METHODS OF DETECTING FAULTS IN ARMATURES.

PRACTICAL METHODS OF DETECTING FAULTS IN ARMATURES.

A method for detecting faults in armature coils is given by Mr. Henry Tinsley in the London Electrician, the details of which are made clear by reference to the diagram in Fig. 1. The method requires the use of a sensitive potentiometer (including a galvanometer), a storage cell and an ammeter. The two wires, *a* and *b*, connecting to the potentiometer may be conveniently joined to two awls or to spikes with insulating handles, these making contact with the segments of the commutator corresponding to the coils to be measured.

In the accompanying figure the armature is shown joined up ready for testing. A storage battery is joined in series with the brushes, with an ammeter, *A*, and with a resistance, *R*. A current is thus allowed to flow through the windings of the armature, which current should be of such a strength that half of its product with the resistance of any one section—that is, the voltage drop of that section—will be sufficiently high to give a suitable reading on the potentiometer. A few amperes will suffice for this. The ammeter should be kept in circuit in order to detect any variation in the current strength, which should be kept constant.

Supposing the armature to be joined up as shown in the figure, then each section of the armature may be tested in turn by placing the points of the two awls leading from the slides, on two adjacent segments of the commutator.

Where the rather elaborate apparatus required by Mr. Tinsley's method is not available, the following method may be substituted with results but little, if any, inferior. The only instrument necessary is a telephone, and the source of current is a continuous current incandescent lighting circuit.

Referring to Fig. 2, *L* are incandescent lamps in circuit with the armature brushes; 5 or 6 of these will be sufficient. *N A B C S M* is a length of bare wire looped back and forth as shown, with the two extremities connected to the brushes. The gauge and length of this wire should be such that the flow of current through it will be about *half* the amount of current flowing through the armature. In other words, its resistance should be about twice the resistance of the armature, if the field of the machine is bipolar. For an ordinary 100-light, 110-volt dynamo, this would be about equivalent to 25 ft. of No. 18 copper wire; a less length of the same size of wire may be used with larger armatures. The different connections are evident from the sketch.

The method of testing is as follows: To commence, contact with one telephone wire is made with the segment adjacent to the brush segment; the other telephone wire is then touched along the looped wire until a point, *A*, is found at which the telephone gives no click. (As shown in Fig. 2, the point, *A*, would correspond to about a 72-part commutator instead of the 8-part one illustrated.) Then the first wire is moved to the next segment, the other remaining where it was, and another point, *B*, found at which again there is no click, and so on. The resistance of the length *A N* of wire, is then equal to the resistance of the first coil, that of *A B* to the second coil, etc. When the points *A*, *B*, *C*, etc., are found, they may be marked by a loop of thread dropped over the wire. Owing to the brush resistance, the first length, *A N*, and the last one, at *M*, may be incorrect, but by turning the armature a few segments, they may then be correctly measured separately.

The points *A*, *B*, *C*, etc., may be most exactly located by touching the looped wire first in one direction and then in another; as the sound of the click will decrease both ways, this will indicate the probable point of no click, which can then be more readily located.

If each of the lengths, *A B*, *B C*, etc., are the same, then the different armature coils are of the same length and insulated from each other. If one or more turns are grounded in a coil, the distance apart of the two marks corresponding to that coil will be shorter; by measuring this length and comparing it to the lengths corresponding to other coils, the number of turns thus short-circuited out may be determined, though defective insulation throughout the coil might give the same indication. If when the telephone wire is moved to an adjacent section there is no material change in the point of no click, the corresponding segments of the commutator, or ends of coil, are short circuited.

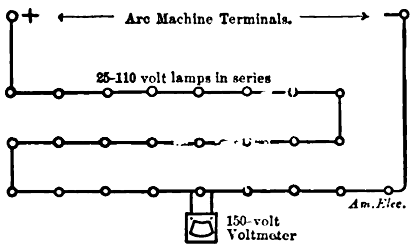
If the resistance of the armature is not approximately known, the proper length of the looped wire (which may be of copper, German silver or iron—whichever is most conveniently at hand) may be determined by trial, by putting an ammeter in circuit alternately between *N* and *K*, and *N* and *A*, and then increasing or decreasing the length of the loop until the current flowing through it is approximately one-third of the current flowing through *K N*. In order to make the distances *A B*, *B C*, etc., conveniently long, the wire should not be of too small section. No. 18 or 20 copper wire will be suitable for smaller machines, the gauge decreasing with larger machines on account of the lower resistance of their armatures.

METHOD OF MEASURING HIGH VOLTAGES BY MEANS OF A LOW READING VOLTMETER.

BY PROF. A. F. MCKISSICK.

The following method of measuring high voltages by means of a low-reading voltmeter has been found very convenient and is sufficiently accurate for all practical purposes.

The method consists in connecting in series between the two points whose difference of potential is to be measured, a number of incandescent lamps of the same voltage, candle power and efficiency, and measuring the pressure around one lamp; then the total voltage will equal that indicated by the voltmeter multiplied by the number of lamps in the series. To illustrate the method, suppose it was desired to measure the difference of potential between the two terminals of an arc circuit of, say, forty arc lamps, and the only available voltmeter was a Weston 150-volt instrument (resistance about 18,000 ohms). As the pressure is in the neighborhood of 2000 volts, connect in series twenty-five incandescent lamps of the same voltage, candle-power and efficiency and then connect this series of lamps between the two terminals of the arc circuit. As each of these lamps would have a potential difference of about eighty volts, all should glow when properly connected. Assuming that the lamps are glowing, connect around one of the lamps the terminals of the Weston voltmeter as shown in the figure. Multiply the reading obtained by the number of lamps—twenty-five in this case—and the result is the pressure between the terminals of the arc circuit.



MEASUREMENT OF HIGH VOLTAGE.

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NOTES.

Are Central Stations Doomed?—Mr. Max Osterberg has in the current number of the *Engineering Magazine* an article with the above caption, in which he contends that block lighting plants can supply current to customers within the block more cheaply than they can be supplied from central stations. Mr. Osterberg bases his argument as to the cheapness of block over central station lighting on the great saving of copper for distribution. In block lighting he advises the employment of gas engines for power, and of storage batteries.

Northwestern Electrical Association.—At the fifth annual meeting of the Northwestern Electrical Association, to be held at Milwaukee, Jan. 20, the following papers will be read: "Incandescent Lamps" by F. S. Terry, Chicago; "Protective Devices for Transformers" by H. C. Wirt, Schenectady, N. Y.; "Gaseous Fuels as a Means of Cheapening Electricity" by Nelson W. Perry, New York; "Transformers" by O. M. Ash, Elkhart, Ind.; "The Garfield Park Electrical Plant" by Foree Bain, Chicago; "Röntgen Ray Phenomena" (Illustrated) by Caryl D. Haskins, Boston; "Electrical Construction Affecting Insurance" by Geo. S. McLaren, Milwaukee; "Safety Devices for Electrical Circuits" by Prof. W. M. Stine, Chicago; "Electrical Supplies" by W. W. Low, Chicago.

Underwriters' National Electric Association.—At the annual meeting of the electrical committee of the Underwriters' National Electric Association, held in New York, Dec. 7, 9 and 10, suggestions to the number of about 200 were received concerning changes in the code of underwriters' inspection rules, many of which were offered by the code committee of the National Conference on Standard Electrical Rules. The changes made were not radical, being in general such as would improve or make clearer existing rules. A code of rules and specifications for the installation of marine plants was adopted at this meeting. The present rules were ordered to be recodified in order to incorporate in their bodies amendments made in the past and at this meeting, it being the opinion of the Association that the rules are now so nearly perfected as to call for this action.

Practical Electrical Instruction.—The Central Branch of the Young Men's Christian Association of Brooklyn, has had evening classes for the practical education of busy young men during the past 21 years, and for several years past has conducted a course in electrical engineering under charge of Prof. Alfred Mackay. The course, which occupies two evenings a week, is intended to give the student a comprehensive insight into the principles of electricity, and a practical knowledge of its applications. The subjects and course of study are as follows: Elementary work in frictional electricity, with experiments and blackboard work; practical problems in dynamic electricity, including equipment and installation of electric lighting and power plants, wiring, storage battery charging, and testing; also design and construction of motors and dynamos. Students have facilities for laboratory practice.

An Electric Water Power Plant in Utah.—Work is rapidly progressing on the hydraulic portion of the power plant of the Pioneer Electric Power Company, of Ogden, Utah, which is to cost $1,500,000 when completed. The initial capacity of the plant will be 10,000 HP, which can, however, be doubled at small proportionate cost. The pipe line, which is now in course of construction, will be six miles long. The piping is six feet in inside diameter and is made of wood with steel bands, there being 87,000 of the latter around four miles of the pipe. It is proposed at first to install five 1000-HP three-phased generators, turbines to drive which are to be supplied by the Risdon Iron Works, of San Francisco, Cal. The current will have a frequency of 60, and will be generated at a voltage of 2300. Transformers will step up this voltage to 15,000 for the transmission of 2000 HP to Salt Lake City, and 25,000 volts may be used for transmission to a mining region thirty to thirty-five miles beyond that place.

Z-Rays.—An enterprising Bowery dime museum proprietor advertises an exhibition of Z-rays, announcing that they are much more wonderful in their properties than the X-rays, which will be relegated to the rear by the new discovery, now for the first time exhibited, etc. The museum proprietor, however, is not alone in the exploitation of the X-ray sensation. A recent writer, who thought he had discovered different varieties of the Röntgen ray, proposed to give these the name of X_1 and X_2-rays. Not to be outdone in this field of nomenclature, it would not be surprising if the discoverer of a stronger kind of Röntgen radiation should propose to dub it the X^x-ray. When the Wurzburg professor, in an excess of modesty and with too great confidence in scientific etiquette, made use—to provisionally designate his great discovery—of the letter which is held so mysterious by the non-mathematical, he could not have known how attractive a bait it would prove to the mongers in sensationalism.

Regulation of Motor Speed.—In a paper read before the November meeting of the American Institute of Electrical Engineers, entitled "Volts vs. Ohms," Mr. H. Ward Leonard described a method, whereby the speed of a motor may be varied from the slowest to the highest speed without the loss of energy incident to the rheostatic method of variation—the latter method besides, admitting practically of only a very limited range. The Leonard system, which has entered into some special use, necessitates a generator for each motor, and is therefore limited to special applications. The armatures of generator and motor form one circuit, the fields of each being excited from an external source of constant potential. The excitation of the motor field is constant, while that of the generator field may be varied to any extent by a rheostat in circuit. The voltage at the generator, and consequently motor, terminals may thus be varied to any desirable extent and therefore the speed of the motor, the only loss entailed being the very small amount in the field rheostat of the generator.

Long Distance Transmission.—Some press despatches describing the inauguration of the Niagara-Buffalo line, were couched in most glowing terms, the reporters apparently having considered it a remarkable innovation to transmit 1000 HP 26 miles. In this connection one of the officers of the Sacramento Electric Company writes us that for several years past the Folsom-Sacramento line has been transmitting from 1800 to 2000 HP a distance of 22½ miles. The above mentioned company is lighting the city of Sacramento, supplying current for incandescent lighting and stationary motors, and for operating 22 miles of electric railway. The shops of the Southern Pacific Railway are run by electric power as well as a number of mills. Attention is also called to another plant that has been in operation in California for several months—that of the San Joaquin Electric Company, transmitting about 1000 HP over a distance of about 46 miles In view of the above cases and of others that might be named, our correspondent believes that to California belong the honors for pioneer work in long distance transmission.

Insurance Rules.—The National Conference on Standard Electrical Rules has placed the drafting a final code of rules in the hands of the following gentlemen, representing the several bodies named: Mr. W. J. Hammer, president of the National Conference, being also a member of the committee; Prof. F. B. Crocker, American Institute of Electrical Engineers; Mr. Frank R. Ford, American Street Railway Association; Capt. William Brophy, National Electric Light Association; Mr. Wm. H. Merrill, Jr., National Board of Fire Underwriters; Mr. E. A. Fitzgerald, Underwriters' National Electric Association; Mr. Alfred Stone, American Institute of Architects; Mr. E. V. French, American Factory Mutual Insurance Company. It is very gratifying to observe the manner in which the various engineering societies and the strong representation of the insurance interests represented in the National Electrical Conference are working in harmony and with such evidences of energy, to bring about a long-wished-for and much-to-be-desired consummation—an authoritative and national code of underwriters' rules that will meet the views of all interested.

Efficiency of the Steam Engine Under Varying Loads.—One of the most stubborn prejudices in steam engineering circles is that multiple expansion engines are less economical than simple engines for service in which the load varies widely. In an article by Prof. W. F. Durand in the June number of the AMERICAN ELECTRICIAN which attracted wide attention, this belief was shown to be unwarranted, and some tests recently made by a large firm of engine builders confirm this view. A customer asked for guarantees as to water consumption for three types of engine—one simple and two compound—of 250 rated horse power each, and for loads varying from 100 to 400 HP. In the accompanying table are given the data which were furnished. The engine "A" was of the simple type, "B" a compound engine with piston valves and clearances of 7 and 9 per cent., and "C" a compound engine with gridiron valves and clearances of 3½ per cent. It will be seen that the compound engines under both extreme overloads and under-loads are the more efficient.

HP.	WATER CONSUMPTION.		
	A	B	C
100	28	23	22
200	24	18½	17
300	25	18½	17½
400	26	25	23

The Memory of Savants.—At a recent meeting of the American Institute of Electrical Engineers, Prof. Rowland, during the course of a discussion on Röntgen rays, was several times at a loss through failure to recall numerical data with which he wished to illustrate his remarks. In one instance considerable amusement was excited when he appealed to one of his former students in the audience for the numerical value of a certain wave length, and was promptly answered, "Give it up." Lack of memory for numerical and other data of mere detail, even though pertaining to the subjects of which they are acknowledged masters, appears to be a characteristic of leaders in scientific thought. Helmholtz had this failing, if we may call it a failing of a mind like his to refuse to carry the additional burden of what may be obtained when needed by reference to a note book or other easily accessible source. Prof. Berthelot, the great French chemist (recently prime minister of France), was notoriously unable to recall in his lectures numerical data, and was apt to startle a new student by helplessly appealing to him for the value of a chemical heat equivalent, the announcement of the determination of which by the inquirer himself may have interested the entire scientific world. If, as maintained by some writers, the memory has a definite limit, and, therefore, storing it with mere data causes the exclusion of what may be of more importance, it would be wise in others than savants to cultivate the habit of forgetting what is not absolutely necessary to retain in the memory.

Carrying Capacity of Cables.—The Electrical Bureau of the National Board of Fire Underwriters has conducted experiments on the heating of cables, the result of which is the accompanying table of carrying capacities for "open work," by which is meant construction that admits of all parts of the surface of the insulating covering of the cable being surrounded by free air. The table applies to all common forms of insulating and protecting coverings used, including rubber, asbestos and weather-proof compounds. These values give the same rise in temperatures as in that of wires from No. 14 to No. 0000 B. & S. already included in the National Insurance Code, and are considered suitable for adoption. The current flows given continued indefinitely will not cause heating of the cables in excess of what they would reach in boiler rooms, or when exposed to the sun of a warm summer's day. In no event will sufficient heating effects be produced to increase the rapidity of deterioration of ordinary forms of insulating coverings.

CIRCULAR MILS.	AMPERES.	CIRCULAR MILS.	AMPERES.
20,000	299	120,000	1,147
30.000	405	130,000	1,217
40,000	503	140,000	1,287
50,000	595	150,000	1,356
60,000	682	160,000	1,423
70,000	765	170,000	1,489
80,000	846	180,000	1,554
90,000	924	190,000	1,618
100,000	1,000	200,000	1,681
110,000	1,075		

A Large Water Power Electric Plant.—All of the necessary preliminary work has been done preparatory to commencing the development of from 100,000 to 200,000 HP from the falls of the St. Lawrence River, near Massena, N. Y. The Grass River, a considerable stream, flows parallel to the St. Lawrence in this vicinity and only three miles away, discharging into the latter at a point seven miles below. In this distance the St. Lawrence falls about 100 ft. over the Long Sault Rapids, while the Grass River only falls about 50 ft. A canal only three and a half miles long will bring the St. Lawrence water to a limestone bluff on the north bank of the Grass River, where it will have a sheer fall of 50 ft. to the river below, which will serve as a tail race to take the water back to the St. Lawrence. It is claimed that a canal for 100,000 HP will cost but $1,000,000. It is intended that factories shall be erected on the spot and a town built there. The power will be utilized to run pulp and other mills, but the greater part will be transformed into electrical energy to be used in electro-chemical processes. The manufacture of calcic carbide will be carried on on a large scale according to a new process recently invented. Stewart & Company, of 40 Wall Street, New York, who are at the head of the enterprise, report that $3,000,000 of bonds have been placed in London, thus ensuring its success. Lieut. F. Jarvis Patten is engineer of the company, Mr. John Bogart, formerly New York State engineer, acting as consulting engineer. Lieut. Patten is now engaged designing the electrical machinery, which will consist of 10,000-HP multiphased generators direct connected to the spindles of turbines of that output. The plans contemplate five or ten electric furnaces to a dynamo, each of 1000 HP or 2000 HP, the latter taking 15,000 amperes at 100 volts.

An American Inventor Abroad.—The London *Electrical Review* announces that the list of foreign orders which have been conferred upon Prof. D. E. Hughes has been added to by the King of Servia, who has presented the Grand Officer's Star and Collar of the Royal Order of Takovo. Our English contemporary believes that but one Englishman living possesses more foreign decorations than Prof. David E. Hughes, and that certainly no electrical man ever met with such distinguished recognition outside his own country. Eight European governments, it states, have done him honor, yet the only instance in which the British Government officially recognized Prof. Hughes was when it appointed him a Commissioner to the Paris exhibition. "No doubt," it adds, "Prof. Hughes's invention, the type printing telegraph, has been more appreciated in foreign telegraphic systems than in this country, but apart from that remarkable instrument, Prof. Hughes has done great services to electrical science. It would not be easy to overrate the importance of the microphone, yet this was freely given to the world. In other directions Prof. Hughes has labored and wrought with success, and we feel sure that there is not a single electrician living who would not rejoice if our own Government were to bestow some honor upon him." It may not be generally known that Prof. Hughes was formerly an American citizen. His parents emigrated to the United States from England when he was a child of seven years, and at the age of 19 he was appointed Professor of Music at the College of Bardstown, Ky., in which college he later occupied the chair of Natural Philosophy. In 1854 he constructed his first typewriting telegraph at Louisville, and during the next several years it was largely used in the United States. In 1857 Prof. Hughes went to Europe in order to introduce his telegraph there, and after several years' labors it was adopted by the French Government for its lines. Later his system and apparatus were adopted in Great Britain and by the governments of Italy, Russia, Prussia, Austria, Bavaria, Wurtemburg, Switzerland and Belgium.

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Measuring Insulation Resistance.

In this issue are several further articles on the measurement of insulation resistance by means of instruments easily obtainable and according to methods extremely simple in their character. That by Mr. W. B. Hale supplements articles by Prof. A. F. McKissick and Mr. W. R. C. Carson, which appeared in previous issues, the three together bringing out the applicability of good commercial voltmeters to measurements that are usually thought to involve laboratory instruments and methods. It should be remembered, however, that the type of instrument referred to is, in fact, a delicate D'Arsonval galvanometer with the added advantage that its readings are expressed in units of current, and are therefore directly applicable, numerically, to the simplest form of Ohm's law. The method of Dr. Oscar May does not differ in principle from the others above mentioned, merely indicating, in addition, how an instrument may be employed that would not be suitable if directly connected between the gronnd and the line whose insulation resistance is to be measured.

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Insurance Rules.

When the movement was started which resulted in the formation of the National Conference on Insurance Rules, many shared in the fear that, instead of the outcome being a single set of rules for insurance inspection, two rival codes would strive for supremacy, with unfortunate results for the electrical contractor thus placed between two fires. This view was based upon the fact that the insurance interests absolutely control the situation through their power to refuse to place insurance on a property having an electrical plant not installed in conformity with the rules laid down by them, though meeting every requirement of another code equally well guarding against the danger of fire. Subsequent events have shown this fear to be ungrounded, and the thanks of the electrical industry are due to the National Conference for the skillful manner in which it has avoided a conflict with the insurance interests that might have had unfortunate results, while nevertheless accomplishing its purpose, as we believe has been done, of introducing changes in such rules of the underwriters' code which bore unnecessarily hard on electrical interests.

With a membership of the highest professional standing representing all branches of the electrical industry, and also including a strong representation of the insurance interests, the National Conference is a body admirably constituted for the task of adjusting differences that almost necessarily will arise between two classes often having conflicting interests. When its present work is ended we believe it would be the part of wisdom for the body to be retained in existence, both in order that its influence may continue toward keeping insurance rules in conformity with the latest electrical advances, and to act as a board of arbitration in case of conflict. Constituted as it is, and in view of the character it has already established for conservatism and fairness, we doubt if at any time its recommendations would be disregarded, but, on the contrary, would be welcomed by the underwriters as authoritative solutions to the vexed problems in insurance inspection that are likely to come up at any time.

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Hysteresis.

In another column the reader will find an article by Mr. E. J. Berg, giving a very clear exposition of the phenomenon of hysteresis, together with data by means of which numerical determinations of the value of losses resulting from it may be made. Though expressed for brevity in algebraic form, the relations between the various factors upon which the loss by hysteresis is dependent may be very easily understood, both from the context and through the numerical examples added. It is scarcely needful to say that hysteresis is an extremely important factor in practical electricity, not only on account of the losses which it entails, but also from the accompanying heating effect. In a recent issue, for example, a case was cited of an armature made of iron of poor hysteretic quality, which heated to such a high temperature through hysteresis that when run on open circuit the insulation was charred. In a 10-light transformer tested by Ryan, the hysteresis loss with an input of 607 watts was 69.7 watts out of a total loss of 82.9 watts; and with one lamp in circuit the hysteresis loss was 93.9 watts out of a total input of 159.1 watts. With iron of the hysteretic quality generally used in modern transformers, the hysteresis loss assumes a much less proportionate amount, but yet may form the greater part of the total loss.

The example cited above shows how important the effects of hysteresis may become in armatures. The loss may vary from one-half to three watts or more per pound of iron in the armatures of continuous current or alternating generators and motors. This fact illustrates the absurdity of basing the efficiency of a generator or motor on its copper loss alone, which was formerly done, since the sum of the hysteresis and eddy losses may considerably exceed the copper loss, and usually does in alternators, and the first named alone may be greater than all the other losses combined. Notwithstanding this fact, a writer has recently proposed a "universal" standard for rating electric railway apparatus, in which comparison of the efficiency of such an apparatus is to be made with respect to the copper resistance alone, the statement being that "the internal resistance, although not a positive indication of electrical losses, is sufficiently near to it, as a rule, to serve as a guide."

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Compressed Air in Street Railway Work.

The article in another column by Prof. W. S. Aldrich on "Compressed Air in Railway Work" will be found of much interest in presenting the favorable aspects of that source of motive power. Abroad the success of the well known Mekarski system is what has doubtless led to the revival in this country of interest in the subject. In this system the air is stored at a pressure of twenty-five atmospheres in reservoirs on the motor cars, and reduced to five atmospheres through regulating valves before being used in the air motors. The loss accompanying such reduction of pressure, 38 per cent. or more, is made good by reheating the air before use. Among the objections urged against this system is the carrying of the dead weight of the reservoirs and the necessity of returning to the central station for recharging, being thus similar to those raised against the use of storage batteries. In Paris, M. Popp has laid down two and one-half miles of a line supplying compressed air at ten atmospheres for street railway traction, the cars to be recharged at any of numerous points along the railway line. In New York City, two compressed air motor cars have been running on the Fort Lee route of the Third Avenue cable road since Aug. 3, 1896, alternating with the cable cars at proper intervals. The air is compressed at the central station to 2500 lbs. per square inch, and stored in Mannesman tubes on the motor car at 2,000 lbs. per square inch. Before using in the motor cylinders it is reduced to 100 or 150 lbs. per square inch, and is then passed through a tank of hot water, and heated to about 300 degs. Since that time three compressed air motor cars have been put into operation on the Lenox Avenue line of the Metropolitan Traction Company, running on regular schedules with the other cars operated by the underground trolley system. The air is stored on the cars at 2000 lbs. pressure, and is also reheated before being used.

Compressed air is thus being given a fair trial in this country, and one which will demonstrate whether, under the conditions here existing, it possesses the elements of economy for street railway traction which its advocates claim. That it has proved satisfactory in a few cases abroad cannot be accepted as an indication that similar success will be attained here. How different the conditions are is shown, in converse, by the history of electric traction here and in Europe—there being 12,133 miles of electric railway in the United States to 564 in all of Europe. We note that Professor Aldrich adopts the singular use, much affected by compressed air advocates, of efficiencies exceeding 100. We believe that it is not denied that heating at the motor receiver is absolutely necessary for commercial efficiency in working compressed air, but instead of this appearing as a disadvantage to the system, by the method of percentages employed it gives rise to numerical efficiencies to which none but discoverers of perpetual motion have hitherto laid claim. To be sure, if the gas consumed for such reheating is not charged up, and the first cost, maintenance and investment charges of the apparatus thus necessited are not considered, such percentages may be correct. On this principle, however, a central station might make a wonderful showing of efficiency by using small generators, though ever so inefficient, and large boosters.

Calculation of Multiphased Transmission Lines.

We have received a number of requests for information in regard to the method of calculation of multiphased transmission lines, and in another column will be found an article on this subject. The three-phased system has been chosen as it possesses advantages over the two-phased system for transmission on account of entailing less inductive drop and less maximum stress on insulation. As all long distance transmissions will employ step-up and step-down transformers, either a two-phased or three-phased generator may be used, it being immaterial if a transformer is wound to send out currents having the same difference of phase as when received or having another phase relation, the same being also true at the step-down end of the line.

As explained elsewhere, the calculation of a transmission line may be made on the basis of a direct current line if inductance is neglected and allowance made for the load factor of the receiving apparatus, and for the saving in copper which the use of the three-phased system involves. The latter is 25 per cent., so that the amount of copper is 75 per cent. of that necessary for a direct current line transmitting the same energy at the same loss. If the receiving apparatus has inductance, some current slips through it without doing any work, the case being similar to the application of force to a crank when it is on a dead center. The value of this "idle" current is expressed in the load factor, and should be added to the useful current before making the calculation of the line by the above method—the useful current being the energy delivered divided by the delivery voltage.

The matter of inductive drop is one which will have to await actual experience before its practical importance can be actually determined. This drop is due to the lines of force generated by the current carried, cutting into and out of the loop of the line with each cycle of alternation, thus generating a back E. M. F. as in a choking coil. As the amount of the inductive drop will vary directly as the current carried, its effect, if uncompensated for, is to cause more or less considerable fluctuations in the delivery voltage, thus affecting the working of apparatus and causing serious fluctuations on lighting circuits. Three methods have been proposed to neutralize inductive drop—by means of condensers, electrolytic cells or over-excited synchronous motors. The first two are not considered to be practicable, at least where the amount of power transmitted is considerable, and the latter method has alone been put into practical use.

The principle of the correction of inductance by an over-excited synchronous motor is that such a machine impresses on the line an E. M. F. opposite to the inductive E. M. F. causing drop, thereby nullifying it in the same manner as would be done by a condenser. In order to be effectual for all loads, such motors should at any time have a corrective effect proportional to the load on the line at that time, which, if the motors are being also commercially employed doing work, is practically impossible. How much of a departure from this requirement will affect the method, and the proportion of the load necessary to be carried by such synchronous motors in order that their effect shall be sufficiently great, are questions to be determined by practice. Should the inductive drop require to be calculated, the operation will be somewhat complex, as it depends upon the size of the wire itself, the distance apart of the several wires, and their relative disposition on the poles. In addition, for rigorous results, the capacity of the line should be calculated and the rise of E. M. F. due to it subtracted from the inductive drop.

The amount of drop for transmission lines is not assumed, as appears to be the general impression, but calculated on such a basis that the yearly cost of energy lost in the line through its resistance, is equal to the annual charge on the cost of the line. In fact, in a formula deduced to determine the most economical weight of copper to use in a line, no drop factor is used—it being necessary to separately calculate the drop after the size of wire has been determined. Should this latter factor then be found too large for the purposes of the transmission, it may be reduced, though in doing so the economy of transmission will also be reduced. If the inductance of the line is also taken into consideration, the problem, as before remarked, becomes one of much complexity, but the simple method here given will, at least, answer for purposes of estimate, and if inductance can be practically neutralized by the use of over-excited synchronous motors, it will give rigorously correct results.

HOW TO MAKE A CONSTANT POTENTIAL ARC LAMP.

BY CECIL P. POOLE.

With a small screw-cutting lathe, a drill chuck and a few drills and other small tools, any mechanic of average ability, having a fair knowledge of electrical apparatus, can, by using the accompanying sketches as working drawings, make a reliable and efficient arc lamp for use on a 110-volt continuous-current circuit, in series with a resistance coil of 8 ohms, or a duplicate lamp and a resistance coil of 1½ ohms, preferably the latter. Fig. 1 shows the frame of the lamp, one-half in cross-section. *A* is the top-plate; *B* is the floor-plate; *C*, *C*, are short side-rods; *D*, *D*, are long side-rods; *E*, the yoke; *F*, the bottom carbon holder; *i*, *j* and *k*, are insulating washers of hard fibre. The under side of the top-plate, *A*, is shown by Fig. 2. It is of cast-iron or brass, and is provided with two lugs, *d*, *d*, ¾ in. in diameter and 1 in. long, drilled and tapped ⅞ in. deep to take ¼-in. gas pipe; a lug, *e*, ⅜ in. in diameter and 1 in. long, drilled and tapped to take a $\frac{5}{32}$-in. machine screw, and a flange around the outer edge, $\frac{1}{16}$ in. thick and ½ in. deep. At diametrically opposite points, two pins, *x*, *x*, are set in the flange; these are of $\frac{1}{16}$-in. steel wire, ½ in. long. The centers of the lugs, *d*, *d*, are 2 ⅜ ins. from the center of the plate, and the center of the lug, *e*, is 2½ ins. from the center of the plate. On the upper side of the plate is a neck (see Fig. 1) 1¼ ins. in diameter outside, and standing 1 in. above the upper surface of the plate. This neck is bored ¾ in. deep, and tapped to fit a ¾-in. gas pipe; below this bore, a hole, $\frac{11}{16}$ in. in diameter, is drilled clear through the plate. A fibre washer, *i*, shown enlarged in Fig. 8, is fitted to this hole; the larger diameter of the washer, *i*, must be such as to allow it to slip down freely in the threaded neck, and the smaller diameter must fit snugly the $\frac{11}{16}$-in. hole at the base of the neck; the bore at the top of the washer is ⅜ in., and the recess in the under side is ½ in. in diameter. The washer is ¼ in. thick, and the flange is ⅛ in. thick.

The short side-rods, *C C*, are pieces of ¼-in. gas pipe, 5¾ ins. long, threaded on the outside at the upper ends and on the *inside* at the lower ends; the long side-rods, *D D*, are similar pieces of gas pipe, 19½ ins. long, threaded on the inside at both ends; the inside threads are ¾ in. long, and the outside thread is an inch long. The short and long side-rods are held together by a steel plug, *l*, 1¾ ins. long, threaded the whole length to correspond with the thread in the side-rods; the washers, *j j*, shown enlarged in Fig. 8, are interposed to insulate the floor-plate, *B*, from the side-rods and top plate. These washers are ¾ in. outer diameter and ½ in. diameter at the neck; the bore is such as to allow the threaded plug, *l*, to slip through without having to screw it; the flange is ⅛ in. thick, and the total thickness is ¼ in.

The floor-plate, *B*, (Figs. 1 and 3) is of brass or iron, 5$\frac{13}{16}$ ins. diameter, ⅛ in. thick, and has a round lug, *c*, ⅜ in. in diameter and ½ in high. There are two ½ in. holes, *b b*, a ⅜ in. hole, *a*, in the center, and a hole through the center of the lug, *c*, threaded for a $\frac{3}{16}$-in. screw. The distances, center to center, are 2⅜ ins. from *a* to each *b* and 1¾ ins., *a* to *c*; the lug, *c*, is 90 degs. from the holes, *b b*. If it is more convenient, the floor-plate may be cut from sheet brass and the lug, *c*, soldered on, or screwed in and riveted.

The yoke, *E* (Figs. 1 and 8), may be cut from a strip of brass 1¼ ins. wide and $\frac{3}{16}$ in. thick; the center hole is ¾ in. and the others ½ in. in diameter; the distances are 2⅜ ins. each way, from center to center of the large hole and each of the smaller ones, corresponding to the location of the lugs on *A*, and the holes through *B*. The carbon holder *F*, is made of two pieces of brass tubing, the long one ½ in. inside diameter and the short one of a size to fit snugly over the long tube; the two are sweated together and riveted as a precaution against the loosening of the solder by the heat from the arc when the carbons are almost burned out. The long piece of tubing is threaded from the end of the short piece ⅜ in. down, and turned down to ⅝ in. outside diameter the balance of its length to allow the nut, *g*, to slip up to the beginning of the thread, and to form a mandrel for the globe holder. A ⅛ in. pin, 1 in. long, must be driven horizontally through the shank of the carbon holder, ⅜ in. below the thread, after the nut is on; the pin holes should be drilled exactly across the center of the tube, so that when the pin is inserted the ends will project from diametrically opposite sides of the shank. This pin is to support the globe-holder, as will be explained farther along. The carbon-holder is 3 ins. long over all, and the short piece of tubing, which forms a sleeve over the holder-tube, is 1 in. long. A set-screw, *h*, serves to clamp the carbon in the holder. The yoke is insulated from the side-rods by washers, *j* and *k*; the former was described above, and

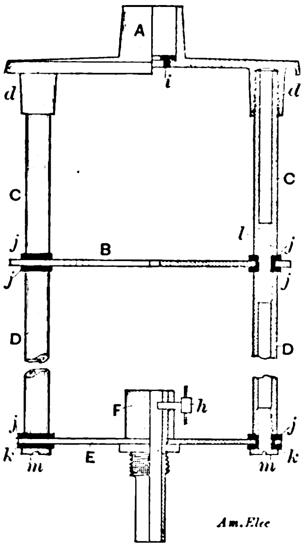

FIG. 1. SEMI-SECTIONAL SKETCH OF FRAME.

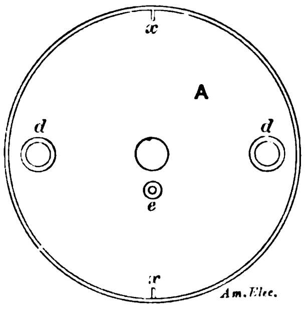

FIG. 2. UNDER SIDE OF TOP-PLATE.

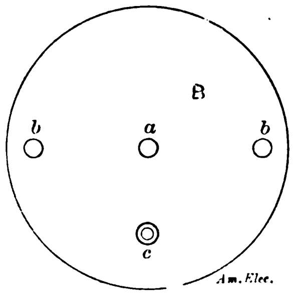

FIG. 3. UPPER SIDE OF FLOOR-PLATE.

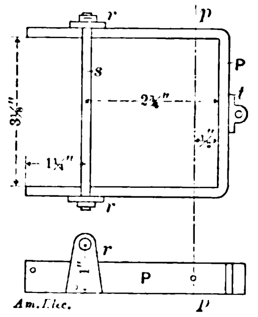

FIG. 4. ELEVATION AND PLAN OF ARMATURE.

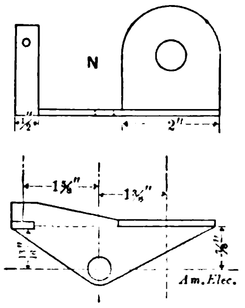

FIG. 5. ELEVATION AND PLAN OF BRASS FRAME.

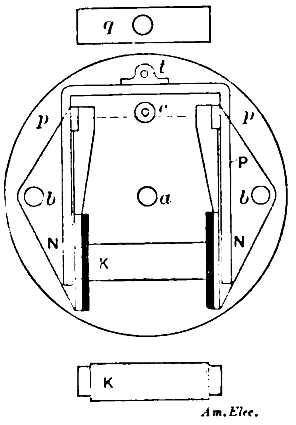

FIG. 6. PLAN VIEW OF MECHANISM, MINUS CLUTCH.

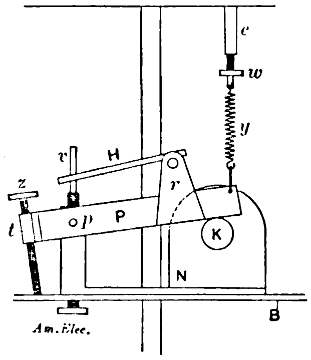

FIG. 7. ELEVATION OF MECHANISM, COMPLETE.

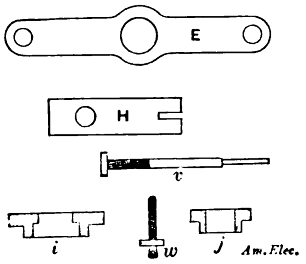

FIG. 8. SMALL PARTS.

the latter is a plain, flat fibre washer 1/8 in. thick, 3/4 in. diameter, with a 1/2 in. hole; screws, *m*, *m*, hold the yoke to the side-rods.

The lamp is of the clutch type, and the moving parts consist of a magnet-armature, a clutch and a carbon-carrying rod. The magnet is a straight, round bar, with a single coil; the core (*K* in Fig. 6) is 3/4 in. in diameter and 3 ins. long, with a shoulder 1/4 in. long at each end, the diameter there being 5/8 in. The core is provided with two insulating heads of fibre 1/8 in. thick, the hole in which is a tight fit on the reduced ends of the core, and after it is wound it is mounted between two brass frames, *N*, *N* (Figs. 5 and 6). Each frame, *N*, has a 1/2-in. hole drilled in its base, the exact location of which may be found by reference to Fig. 5. These frames have standards to which is pivoted the armature, *P* (Figs. 4, 6 and 7). The thickness of the metal is 1/8 in. throughout. The back ends of the frames, *N*, *N*, are held down by a cross-bar, *q* (Fig. 6), which has a 3/8-in. hole in the center to allow the lug, *c*, to come through. The lug is threaded on the outside to take a nut to hold down the cross-bar, *q*. The bar is 1/8 in. thick, 3/4 in. wide and a trifle over 2 3/4 ins. long so that the ends may be filed to fit exactly between the pivot standards of the frames, *N*, *N*.

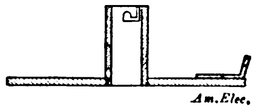

FIG. 9. CROSS-SECTION OF GLOBE-HOLDER.

The armature is a piece of flat Norway iron, 3/16, in. thick, 5/8 in. wide and 11 1/4 ins. long, bent into a **U**, as shown in Fig. 4, and provided with two ears, *r*, *r*, 1/8 in. thick, which carry a round rod, *s*, of steel, 3/16 in. diameter. At the back end a clip, *t*, of brass, is riveted on; this piece has a hole through it, tapped for a 3/16-in. machine screw. Pivot holes, whose centers coincide with the dotted line, *p*, *p*, are drilled in the sides of the armature. The dimensions specified in the drawing must be carefully observed.

The clutch *H* (Fig. 8), is a flat piece of brass 1/8 in. thick, 3/4 in. wide and 2 3/4 ins. long, with a 7/16 in. hole drilled 3/4 in. from one end and a 1/8 in. slot, 1/2 in. deep, sawed in the other end. The edges of the hole must be very slightly rounded to prevent the clutch from cutting into the carbon rod; *v* is a regulating screw to trip the clutch; it is 3 1/2 ins. long over all, 3/16 in. diameter at the threaded part and 1/8 in. diameter beyond the shoulder. The shoulder is one inch from the end. The armature, frames, clutch and carbon rod are shown assembled in Fig. 7. The spring, *y*, which pulls the armature upward is adjusted by means of the screw, *w*, which screws into the lug, *e*, on the top-plate. The screw is 5/32 in. diameter and the threaded end is an inch long. The play of the armature is limited by the back-screw, *z*, by means of which the length of arc first struck is adjusted; the screw, *v*, and the spring, *y*, regulates the length of arc while burning. The spring is attached to a stout brass wire strung from limb to limb of the armature.

The magnet is wound with No. 30 double cotton-covered magnet wire, 32 layers deep, and 125 turns long, the starting end being connected with the core and the outer end with the bottom carbon holder. Binding posts may be put on if desired, but the writer prefers to carry a piece of No. 12 rubber-covered and braided wire from the yoke up alongside one of the side-rods, making this the negative lamp termiual; the outer end of the magnet coil may be connected to this terminal by means of a piece of stout wire brought through the floor-plate, *B*, of the lamp, the hole being bushed with insulation, and the positive terminal may be a binding post screwed in the floor-plate (which is in electrical contact with the carbon rod.)

The case of the lamp is a piece of thin sheet brass, 6 ins. × 19 ins., bent into a 6-in. tube and riveted at the lap; at one end of the tube thus formed, and diametrically opposite each other, are bayonet slots which engage with the two pins projecting inwardly from the flange of the top plate of the lamp. The carbon rod is a piece of brass tubing 3/8 in. diameter outside, 24 ins. long, with a 1/16-in. wall. The upper carbon holder can be purchased for a small sum and is not worth the trouble of making. The ball and shank must be made to fit the carbon-holder and the bore of the carbon rod; the shank should be an inch long, very slightly tapered. Drill a 1/16-in. hole clear through the rod, 1/2 in. from the end, before inserting the shank; then tin the shank and the inside of the end of the carbon rod, drive the shank in and solder through the holes.

The globe-holder (Fig. 9) consists of a disk of brass (or iron) 3/16 in. thick and 5 ins. in diameter, having a piece of brass tubing screwed into its center, and three lips riveted at equi-distant points around the edge. The tube in the center must fit snugly over the shank of the carbon-holder (Fig. 1), and it has two bayonet slots at the upper end which fit over the ends of the pin driven transversely through the carbon-holder shank. This tube must measure 1 1/2 ins. long above the disk. The ears are simple brass strips each 1/8 in. thick, 1/2 in. wide and 2 ins. long, with 1/2 in. of its length bent up almost at right angles to the balance; 3/16-in. thumb-screws in the up-turned lips serve to hold the globe by its rim.

Two arc lamps such as the one above described will work together, in series with a resistance coil of 1 1/2 ohms, on any 110-volt continuous-current circuit.

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The Electric Railway in Europe.

During the past year, the number of electric railways in Europe has increased from 70 to 111, the total length of lines going up from 437 1/4 miles to 564. Germany has a total length of 255 miles and 857 motor cars; France, 82 1/2 miles and 223 cars; England, 67 miles and 168 cars, and Switzerland, 29 1/2 miles and 86 cars. Bulgaria and Denmark are the only countries which have no line with electric traction. Of the 111 lines, 91 are on the overhead wire system, 9 have a central rail, 8 accumulators, and 3 an underground conduit. It may be added that the United States has 12,133 miles of electric railway and 26,242 motor cars.

AMERICAN TELEPHONE PRACTICE.

THE TELEPHONE RECEIVER.

BY KEMPSTER B. MILLER.

To construct a receiver capable of reproducing speech is a very simple matter. In fact, nearly any electromagnet, with a comparatively light iron armature, such as is commonly used in electric bells and telegraph instruments, may be made to reproduce, with more or less distinctness, sounds uttered in the vicinity of a transmitting apparatus with which it is in circuit. It has proved more difficult, however, to construct a receiving instrument which will reproduce speech *well*, and at the same time be practically successful in everyday use.

The simple bar magnet with a thin iron diaphragm in close proximity to one of its poles, used in the early experiments in telephony, leaves little to be desired in point of theory, and this form has been very generally adhered to throughout this country. The instrument has been made much more sensitive than were the early forms, but this result has been accomplished more by better mechanical and electrical design, and the use of better materials, than by any departure from the original principles of its action.

Aside from actual talking efficiency many considerations of a purely mechanical nature enter into the design of a good telephone receiver. It should be durable and capable of withstanding the rough usage to which it will necessarily be subjected by careless or ignorant users. It should be of such construction that its adjustment will not be changed by mechanical shocks, or by changes in temperature. It should be of such external configuration as to enable it to be conveniently placed to the ear. The chamber in which the diaphragm vibrates should be small and of such shape as not to muffle the sound. The binding posts should be so securely fastened in as to prevent their becoming loose and twisting off the wires inside the receiver shell; and the construction should be so simple as to render the replacing of any damaged part an easy matter.

By far the greater number of receivers used in America are of the single-pole type. The particular form shown in Fig. 1, has proved very efficient and is now largely used by the American Bell Telephone Company. Its chief merit lies in its simplicity.

In Fig. 1, *M* is a compound bar magnet, composed of two pairs of separately magnetized steel bars arranged with like poles together. Between the pairs of bars is clamped a soft iron pole piece, *P*, at one end, and a similarly shaped iron block, *Q*, at the other end. These parts are firmly bound together by the two screws, *SS*. On the end of the pole piece is slipped a coil of wire, *G*. This coil is usually wound with two parallel No. 38 B. & S. silk-insulated copper wires, and has a total resistance of about 75 ohms.

The magnet is incased in a shell of hard rubber, composed of two pieces, *A* and *B*, which screw together and clamp between them the diaphragm, *D*, of thin sheet iron. The piece, *B*, is hollowed out as shown, to form a convenient ear-piece. A tail-piece, *T*, carrying two binding posts, *J J*, fits over the end of the case opposite the ear-piece *B*, and is held in place by a screw, *E*. This screw engages a threaded hole in the block, *Q*, and serves not only to hold the tail-piece in place, but to bind the magnet securely to the shell. Soldered to the binding posts are heavy leading-in wires, *WW*, which pass along the sides of the magnet and are soldered to the respective terminals of the fine wire forming the coil.

The diaphragm of this instrument is about $\frac{1}{60}$ in. in thickness, and $2\frac{1}{4}$ ins. in diameter. The free portion of the diaphragm is but $1\frac{1}{4}$ ins. in diameter.

In some single-pole receivers the old style of magnet, consisting of a single cylindrical bar of steel, is still used, instead of the compound magnet formed of several separately magnetized bars, but with generally inferior results, owing to its weaker and less permanent magnetic fields.

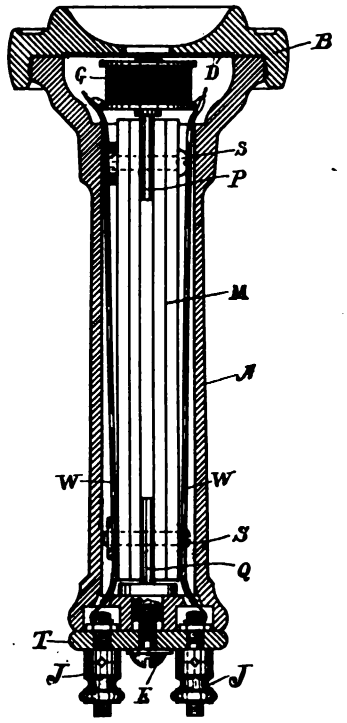


FIG. 1.—COMPOUND BAR MAGNET RECEIVER.

In the bipolar receivers which are now coming more generally into use, the object is to strengthen the magnetic field of force in which the diaphragm vibrates, by presenting both poles of the magnet to the diaphragm. The length of the path of the lines of force though the air is thus greatly shortened and the field of force is concentrated at the point where it will be most effective.

This type is well illustrated in Fig. 2, which represents the instrument now generally adopted, made by the Western Telephone Construction Company. The shell, *A*, and ear piece, *B*, are of hard rubber and clamp between them the soft iron diaphragm *D*, as in the instrument described above.

The magnet consists of two pairs of separately magnetized steel bars, *F F* and *F′F′*, the separate bars in each pair being laid with like poles together, so that each pair forms in itself a compound bar magnet. These two compound bar magnets are so laid together that the north pole of one is opposite the south pole of the other. The two pairs of bars are held apart at one end by the hard rubber adjustment block, *H*, and at the other end by the soft iron block, *I*. On each side of the block, *H*, and between it and the pairs of bar magnets, are the soft iron pole pieces, *P P*, on which are wound the coils, *G G*.

The block, *H*, has two segmental flanges projecting out beyond the sides of the magnet bars. These flanges are screw-threaded on their circumferential surfaces so as to engage a thread, *g*, on the inner surface of the shell, *A*. The magnet may thus be adjusted toward or from the diaphragm by turning it in the shell, *A*.

A tail-piece, *T*, of hard rubber is so shouldered as to fit into the small end of the receiver shell, and is prevented from turning in its place by small lugs fitting into notches in the shell. A screw, *O*, extends through the tail-piece and clamps the magnet into any position to which it has been adjusted. To the binding posts, *J J*, are soldered heavy leading-in wires, *W W*, which pass through holes in the adjustment block, *H*, and are soldered to the terminals of the fine magnet wire. These heavy wires, *W W*, are firmly knotted after passing through the block, *H*, in order to prevent any mechanical strain coming on the hair-like wires of the magnet coils, when the tail-piece is removed. Sufficient slack is left in the leading-in wires to allow the removal of the tail-piece a short distance, to give access to the end of the magnet for purposes of adjustment.

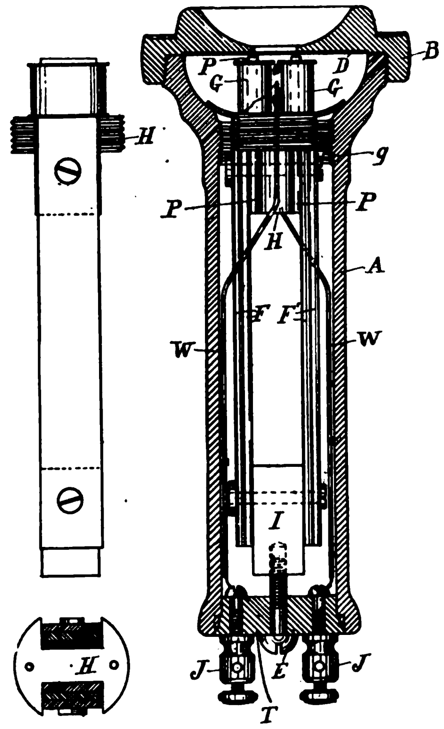


FIG. 2.—BIPOLAR BAR MAGNET RECEIVER.

In many forms of receiving instruments much trouble is experienced in keeping permanent the adjustment between the magnet and the diaphragm. This is due to the fact that steel and hard rubber differ widely as to their amounts of expansion or contraction under changes in temperature. In instruments where the magnet is rigidly secured to the shell only at a point at considerable distance from the diaphragm, the unequal expansion or contraction of the magnet and the shell causes the distance between the pole piece and the diaphragm to vary with every change in temperature. A sudden change will thus often render a receiver inoperative.

This source of trouble has been practically removed from the receiver shown in Fig. 2 by securing the magnet to the shell at a point so close to the diaphragm that the difference in expansion or contraction between the hard rubber and steel can hardly be noticed.

Another way of obviating this difficulty, largely used in European countries, is to construct the shell holding the diaphragm of some metal having nearly the same coefficient of expansion as the steel magnets. This method has not, so far as I am aware, been used to any great extent in this country.

Fig. 3 shows one of the early forms of bi-polar receivers. This was devised in 1881 by Clement Ader, of Paris, France, and is with some modifications largely used in France and other European countries to-day. This embodies the results of one of the few successful attempts at increasing the electrical efficiency of the telephone receiver. The magnet, *B*, is ringshaped, and has fastened to its poles two L-shaped pole pieces carrying coils, *C C*. The box, *R*, enclosing the pole pieces and coils, is secured to the magnet by screws, *E E*, and is screw-threaded at *G*, so as to engage a corresponding screw-thread on the inner surface of the cap, *S*, which has a flaring portion, *H*, forming an ear-piece. The diaphragm, *D*, is clamped between the pieces, *R* and *S*, as in the American instruments described above.

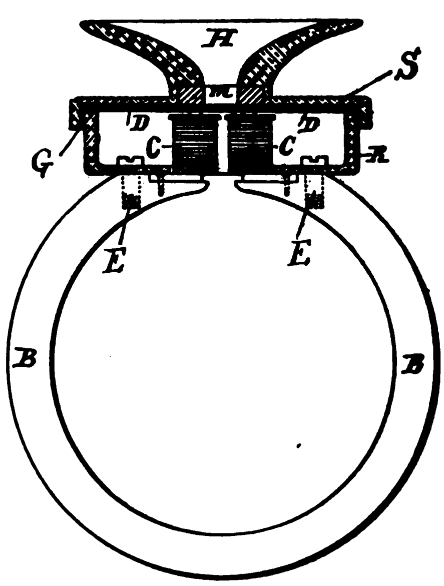


FIG. 3.—ADER BIPOLAR RECEIVER.

Surrounding the opening, leading from the diaphragm to the ear-piece, is a ring, *m*, of soft iron, and in this ring lies the chief virtue of Ader's invention. The additional mass of iron placed near the poles of the magnet affords a more ready path for the lines of force, and their number is thus increased. The diaphragm, therefore, moves in a stronger field of force, and the power of the receiver is correspondingly augmented.

It has been suggested, by eminent English authority, that the tendency of telephone practice should be toward decreasing rather than increasing the sensitiveness of the receiver, as the very delicate receivers are more susceptible to the extraneous disturbances which are so common, especially on lines of faulty construction. It would seem, however, that this is simply avoiding one fault by creating another. The proper remedy lies in eliminating the disturbances rather than in attempting not to notice them.

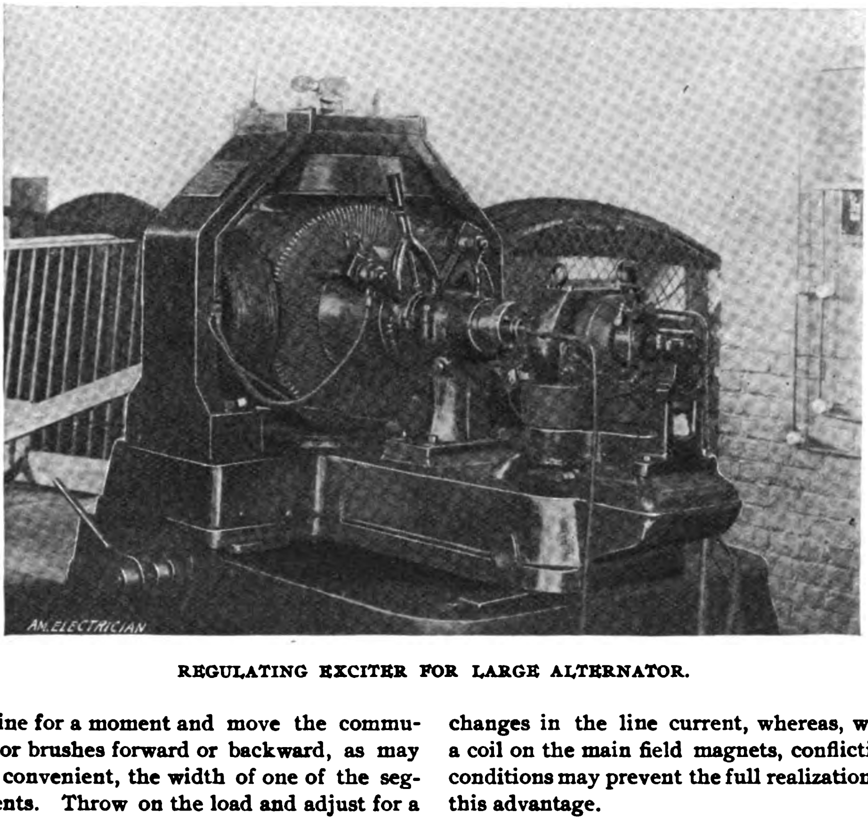
FAULTS AND HOW TO FIND THEM.

FAULTS IN REGULATORS.

Alternate current regulation is never so satisfactory as direct current regulation and the automatic regulating devices have to be adjusted with more care and attended to more frequently.

The best known regulator for alternate current machinery is the compounding coil; unlike the direct current compounding coil, it requires considerable attention. In any case, where the magnetism of the field must be varied by a loop in series with the line, the current impulses in that loop must be rectified so that they are all in one direction. This requires a commutator.

One of the most common troubles is the extremely rapid falling off in voltage as the load comes on, sometimes amounting to as much as fifty per cent. of the total. This is due to the series field opposing instead of helping the exciter. The remedy is very simple. Throw the load on to another machine for a moment and move the commutator brushes forward or backward, as may be convenient, the width of one of the segments. Throw on the load and adjust for a position of sparkless running.



REGULATING EXCITER FOR LARGE ALTERNATOR.

This reverses the series field terminals and the current will now traverse them correctly. The adjustment just indicated may be made without throwing off the load, but it is at the expense of burning the commutor by flashing arcs. If dexterously done, however, the damage will be slight.

If the load of the alternator is inductive, such as a rotary transformer or motor load, and the inductance thereof a variable, the action of the compounding coil will be so unsatisfactory that it is a question whether its utility justifies its use. The action of an inductive load is to shift the phase of the current and it will then be out of step with the commutator, or rectifier as it is sometimes called. The latter will then spark and, worse than that, the voltage will not rise as it should and may even go down if the lag is great. On the readjustment of the brushes all will be well again.

It will be readily seen if the load is a rapidly varying one, such as a street railway load, the inductance will change so frequently that the commutator will require constant attention. For this trouble there is no ready remedy other than radical change of the regulating devices. The difficulty is more apparent on multiphase machines where a large motor load is frequently present.

A convenient method of compounding an alternator is to pass the rectified line current through series coils on the exciter field magnet. This has a number of advantages over the usual method. In the first place, it reduces the inductance of the machine as a whole, because both less currents and less turns suffice to do the compounding. Second, the lesser current is more readily rectified by the commutator, and should it lag in phase from any cause, less sparking will result. Moreover, if carefully designed, the exciter field may be made very sensitive to changes in the line current, whereas, with a coil on the main field magnets, conflicting conditions may prevent the full realization of this advantage.

One of the most satisfactory methods of controlling the voltage of an alternator is by means of an electro-mechanical regulator. The controlling resistance is placed within a box and the spindle which operates the contact arm is connected to a large ratchet wheel, which can be driven in either direction by suitable pawls oscillating backward and forward over the toothed surface of the wheel. The pawls are driven by a light belt from the engine shaft or any convenient source of power. These pawls are operated, each by its own electromagnet, which is supplied with current from some source of direct current, either a battery or the exciter. In circuit with these magnets is a relay which can so operate its contact that it can send current into either of the magnets. This contact is actuated by a laminated plunger which works in a coil of fine wire. This coil is connected directly across the 110-volt mains of a transformer connected with the alternator. When the voltage rises, contact is made and current is sent through the appropriate magnet, which attracts and holds its pawl against the regulator wheel till the voltage is restored. When the voltage falls, contact is made, sending current to the other magnet, and the rheostat resistance is again appropriately altered.

These magnets have the annoying trick of sticking fast to their armatures when they should not do so. To prevent this, the magnets should be placed a sufficient distance away from the pawls to allow a clearance when the latter are pressed against the wheel. With large alternators requiring large exciting machines, the rheostats are so heavy that the pawl-magnets take a great deal of current and the arcing at the relay interferes with its action.

This has been obviated by using a small dynamo to excite the fields of the exciter, the field rheostat of the small dynamo thus controlling the voltage of, it may be, a 5000-light alternator. Such an arrangement is shown in the accompanying illustration. The whole controlling apprratus may thus be small and well built and susceptible of very delicate adjustment. A convenient indicator to tell whether the indicator is working properly is to place in series with each pawl-magnet a lamp which serves both as a non-inductive resistance to protect the magnet from excesive current, and as an indicator to tell whether or not that magnet is working. By making one lamp green and the other red, the station attendant can tell at once whether the voltage is too high or too low and whether or not the regulator is controlling it. This device is much used in stations employing shunt or alternating current dynamos and is very efficient.

ELECTRIC RAILWAY APPARATUS.

THE BONTA BRAKE.

A new electric railway brake recently perfected, the invention of Mr. A. K. Bonta, of the North Hudson County Railway, is entirely electrical in its action and requires only a few additional contacts on the ordinary controller reversing cylinder. This brake contains so much promise that every railway man should become thoroughly conversant with it. It is adapted to the K or the K2 controller and can be readily installed upon either of them.

The principle, briefly expressed, is to connect the two motors of the car in such a way that one as a dynamo drives its mate in a reverse direction as a motor. In other words, the motors are connected to "buck" each other. This action will take place whether the trolley is on or not, and therefore the brake is operative under any conditions when the car is in motion and the motors are in good order.

There are two distinct braking influences. First, the back drag of the dynamo, and second, the back torque of the motor. The braking action is extremely powerful, so much so that the brake is not intended for continuous use; but rather for an emergency stop. With the brake as now manufactured, a little register is connected to the reversing spindle which records the number of times the brake has been used, and is a check on the motorman.

If the fuse should blow or the trolley come off, on an ordinary electric equipment, there is still a recourse at hand even if the brakes should fail. Reverse the motors and turn the controller full on. One machine will then operate as a dynamo and the other as a motor and the car will come to a standstill with a jerk.

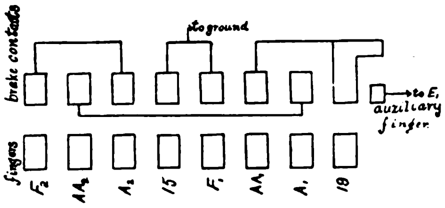


FIG. 1.—CONTACTS OF BONTA BRAKE.

If this action were sure to take place promptly and with absolute certainty, it would be an admirable emergency stop in itself, but unfortunately it is not reliable. The motors may build up slowly or they may build up together so evenly that there will be a momentary dispute between them as to which shall be the dynamo and which the motor. In an emergency even seconds are precious and there must be no delay in a struggle for supremacy between the motors.

The Bonta brake is simply a method of connecting the motors so that they will buck each other with promptness and certainty.

In order to connect two machines that normally operate as motors in close circuit to produce bucking, the terminals of both armatures must be be reversed. That of the dynamo, because it will not generate unless this is done, for although the current be reversed in the armature it must continue to traverse the field in the same direction or the machine will kill its own field instead of building it up. The motor armature terminals must also be reversed, for the direction of rotation is to be backward.

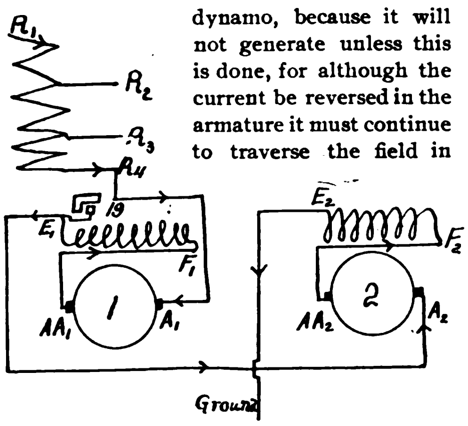


FIG. 2.—CONTROLLER AT FIRST NOTCH.

It is clear then that if the two motors are thus close circuited on each other, each will be under exactly the same electrical and mechanical conditions, and if they build up together, there is no reason why one should buck the other. But this condition is one of unstable equilibrium and presently one machine will lose its voltage in some degree and will immediately become a motor. If the connections are made at once, the action will take place more quickly, and if the line current is properly connected to the system, it can be made to strengthen the dynamo field and tend to weaken the motor field and thus accelerate the bucking.

These connections are accomplished by a set of contacts on the reversing cylinder and an extra finger which bears upon them when the motors are connected to buck. The arrangement of these contacts is shown in Fig. 1, the arrangement being the same as on the regular General Electric controller diagrams. The ground connection of the middle contact plates is obtained by drilling through the spindle and thus grounding on the controller case.

The auxiliary finger, which is connected to a wire to the middle pole of the three-throw cut-out switch in the bottom of the case, makes contact with the lowest plate when the brake is "on."

If we consult a K or K2 controller diagram, we shall find the condition of affairs on the first notch like that shown in Fig. 2. Both motors are operating as motors and are in series with all of the resistance. The state of affairs when the brake is on is shown in Fig. 3.

Comparing Fig. 3 with Fig. 2, it will be seen that when No. 2 acts as a dynamo, its E. M. F. will send a current in the reverse direction from the current it has been receiving as a motor. This would kill its field were not the terminals of that member reversed also.

The motor No. 1 has its armature terminals reversed also, far it is to rotate in a reverse direction. The connections of the line current may now be noted, and it will be seen at once that they are such that the current flowing therefrom will strengthen the dynamo field and weaken the motor field, thus making No. 2 the dynamo beyond all dispute.

The operation is first to throw off the controller and thus release the reverse lever; second, throw the latter to the rear as far as it will go, when the connections of Fig. 3 will be made. The motors will probably buck at once, and this action can be accelerated and intensified by turning on current by the controller handle.

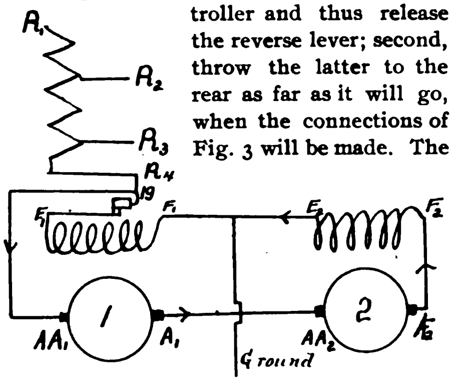


FIG. 3.—BRAKE APPLIED.

The reversing cylinder has two sets of brake contacts, so that the brake may be applied whether the car is going backward or forward. From what has been said, it will be easy to comprehend how the contacts have been made.

The brake equipment as supplied comprises a new reversing cylinder with the brake contacts, an extra contact finger to make the connection to *e*, and a register which is arranged to connect to the reversing spindle. The old guard that is cast in the top of the controller box must be planed off, and a new one that is supplied for the purpose securely riveted in place. The auxiliary finger must be secured in place and connected by its lead to *E*, the middle pole of the three-throw switch. All of the fingers must be bent in a trifle, as the new cylinder is ¼ in. smaller in diameter than the old one. The stiffening band in the controller cover must be cut away opposite the reversing cylinder in order to prevent contact with the new plates, and consequent short circuit. The rest of the installation is easy and obvious.

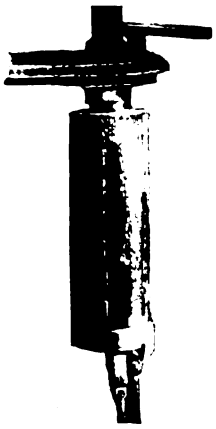


FIG. 4.—BONTA BRAKE.

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INTERIOR WIRING.

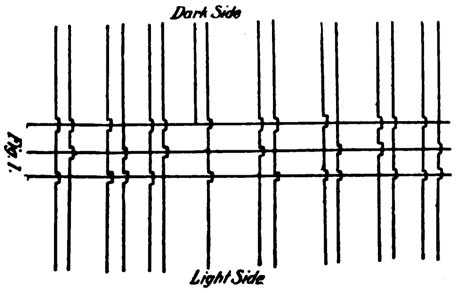
THE THREE-WIRE SYSTEM.

The ideal method of wiring a building by the three-wire system consists in complete subdivision. By this is meant that of every group of lamps, however small, equal numbers are placed on either side of the neutral wire. This effectually prevents unbalancing of the system except by deliberate intent. Unfortunately, like most things desirable, this construction is expensive, as it necessitates the labor and material of running the third wire to every group of lamps. It has been stated by competent authority to be poor engineering to economize on neutral copper in buildings, that saving being preferably on the street mains, but the expense of running a widely subdivided neutral rather than the actual cost of the copper raises a serious question as to whether the first cost is justified by the advantage gained.

By the use of certain approximations and by careful design, practically equivalent results may be obtained, and some of these will now be discussed.

In large office buildings there are usually on each floor long corridors, from either side of which branch small rooms utilized as business offices. This system can be advantageously wired by running the three wires down the length of the corridor and branching two-wire systems to the right and left to supply the offices. Even this must be done with discrimination. If one side of the building abut on an adjacent one, as is usually the case, that side of the building will be dark a much greater portion of the time than the other, Therefore a system of wiring as shown in Fig. 1 would be advisable. This divides the rooms on the dark and light sides of the building equally on either side of the three-wire system, and insures an equal division of load. By supplementing this division by throwing alternate floors on either side of the neutral, the load will be almost as evenly divided as would be possible by the ideal method.

Corridor lights and public lights that burn at definitely known times or continuously, should be evenly divided between the two sides of the circuit. It should not be sufficient to alternate the various floors of public lights on either side. Each floor should be subdivided. There is really no excuse for not doing this, as in most cases the neutral wire is very accessible, as it usually runs the length of the corridor.



THREE-WIRE CIRCUITS.

It is not economical to light large office buildings from other sources than an isolated plant, and therefore all buildings of this nature should be installed with regard to the ultimate adoption of this source of current. If the two-wire system is to be used until the expiration of the three-wire patent (1900), the neutral wire should be twice the size of the outer mains, for then the two outer mains can be connected together as one positive, using the neutral as a common return.

In theatres or buildings having large auditoriums lighted by chandeliers of many lights, it is imperative that the lights of such fixtures be equally divided between the sides of the three-wire system. If the chandelier be subdivided in switch control, the switch must be a three wire one if the number of lights exceeds ten or fifteen. If the number of lights on each switch be less than ten, the switches can be two-pole and conveniently distributed on either side of the neutral.

In small buildings, especially those belonging to and occupied by one concern, the more minute the subdivision the better, as such lights are liable to be burned on one side of the system to the exclusion of the other through perfectly natural causes. Care and judgment must be used and the actual burning of the lights must be predicted in so far as possible, and corresponding arrangements made.

In the case of a theatre there are four large rows of stage lights—the foot lights, the side lights and the lights in the flies. The foot lights and the fly lights are used separately and should be divided, but the side lights are always used together and it will be perfectly proper to place one set on one side of the neutral and one on the other, for they balance each other.

In electric sign work it is not necessary to minutely subdivide each letter, for unless special arrangements are made, the whole sign is to be used at once. Therefore, a good construction would be to place alternate letters on either side of the system, having due regard of the number of lights that go to make up a letter. An I and a U on one side would probably balance a B on the other. The aim should be to avoid placing any one bank of lamps that is liable at any time to be used singly, on one side of the system.

Insulation of the wiring, a matter of serious care at any time, must be doubly reinforced when making a three-wire installation. It is the common practice of large stations to ground their neutral wire, and in some localities it is grounded at every street corner. Therefore, every water or gas pipe is a dead short circuit of 110 volts for either side of the two outer wires. Therefore, corresponding care must be used, not only because of the fact just cited but because the 220 volts require more careful insulation than a 110-volt system. In places where the neutral wire is not grounded, vigilance should not be relaxed, for it is liable to be deliberately grounded by station men if the system becomes greatly unbalanced or it is grounded by private individuals for one purpose or another. The writer has known of cases where the neutral wire was grounded for convenience in transmitting current about the place, one wire being run and the current returned through the nearest gas or water pipe.

There is now a practice that is extensively used whereby current is distributed at a pressure of 220 volts and delivered to a building at 110 volts for use on the three-wire plan, and this is done without the use of a third wire, thus effecting a large saving in copper.

Briefly, this is done by means of what is called a balance coil. These are divided into two classes, the rotary and the static balance coil. The former is for direct and the latter for alternate currents. The construction of these is somewhat complicated and must be reserved for another article.

KINKS WITH THE STEAM ENGINE INDICATOR.

The indicator, while it is primarily intended for indicating the performance of an engine, can be utilized for a number of other purposes and will frequently serve to assist an engineer out of a predicament. This article will be devoted to some of the special employments to which the instrument may be put.

There is a convenient method for measuring the speed of an engine by the use of the indicator which may be exceedingly useful in case the speed counter is not at hand, as is often the case, and the speed of the engine is high.

The indicator being connected to the engine at either end of the cylinder, the procedure is as follows: Disconnect the cord from the reducing rig and take it in the hand as shown in Fig. 1. At a given instant, press the pencil motion against the drum, at the same time drawing out the cord with the hand, releasing the pencil motion after a certain definite time has elapsed. A record such as is shown in Fig. 2 will be produced. It is obvious that the number of crests to the jagged record indicate the number of revolutions that have taken place in the interval, and from this the speed of the engine can be calculated.

The engineer who has handled an indicator but little sometimes finds it difficult to appreciate the fact that it may be used with advantage in scores of other places about the plant than the engine. Oftentimes many a "freak" card may be explained by taking a diagram with the indicator tapped into the pipe connecting the two cylinders. Where a receiver is used, this application of the indicator would show little or nothing, as the pressure in such a receptacle is quite constant. In the steam pipe before it enters the engine the indicator has been used to demonstrate the necessity for a steam reservoir or cushion. A Bourdon gauge attached to a shaking steam pipe will be as much affected by mechanical jar as by variable pressure, but by means of the indicator the momentary drop of pressure on admission, or the sudden use at cut-off due to the inertia of the steam, can be shown and measured, and judgment can be passed as to whether or not a reservoir will lessen these evils. Indicators can be used on steam pumps, applied to either the steam or water cylinder, on gas engines or any appliance where there is a variable pressure to be measured. Care must be always taken to anticipate the pressure nearly enough to use a spring of proper scale. The pressure can be recorded with reference to any mechanical event by using a suitable reducing motion connected to the mechanism with reference to which the record is to be taken.

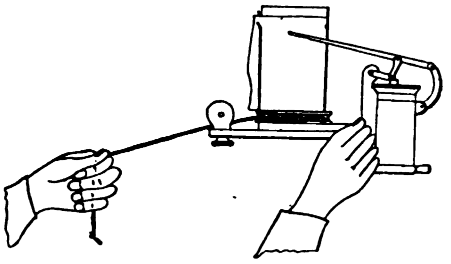


FIG. 1.—MEASURING SPEED OF ENGINE.

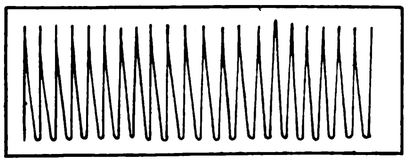


FIG. 2.—ENGINE SPEED CARD.

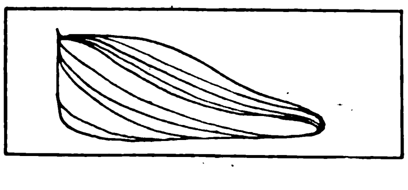


FIG. 3.—ENGINE REGULATING CARD.

Governor cards indicate almost as much about the regulation of an engine as do the ordinary cards about the events of the stroke. Fig. 3 shows such a card. The method of obtaining it is as follows: Load the engine with some power-consuming device that can be thrown off either instantly or gradually, as may be preferred. A dynamo is very suitable for this purpose. Have the indicators ready, the drums oscillating and the pencil movement in motion. Let there be two men, one to operate the indicators and the other to manipulate the engine load. At a given instant let the load be suddenly varied and at the same time press the pencil motions of the indicators against their drums, having previously taken the record with the original load. Hold the pencil motion on until the engine seems to have attained a steady speed and a record similar to that of Fig. 3 will result.

The card thus taken is significant of many things. On it there are two cards which are made quite plain by frequent retracing. One lies within the other. These are the initial and final load cards. The number of complete cards between these two, or rather, other than these two, is the number of complete revolutions that the engine made before it succeeded in readjusting itself to the new load. On a good engine this number is very small.

The cards serve to show also how the engine accomplished its speed control, whether by legitimate control of the cut-off or by varying some of the other events also, the latter always being more or less objectionable. A governor card loses its value as such if the load is gradually varied, for the intermediate cards will then indicate a gradual and proper control of the steam distribution to fit the gradually increasing or diminishing load, as the case may be.

If, however, there are but two loads, a maximum initial load and a minimum final one, any card between the two indicative of these loads is one of transition and taken while the engine was regulating.

The necessity of being able to take cards at a given instant has been shown in the foregoing, and this need would be more apparent in a test on a multiple expansion engine with two indicators on each cylinder. Without such simultaneous record, the result would lose much of its value and the cards would certainly not be comparative. This simultaneous action can be conveniently accomplished by the use of the electromagnet. An electromagnet can be so placed on each indicator that when the former receives current it will press the pencil motion against the drum, and on the breaking of the circuit the pencil motion can readily be caused to fly back by means of a spring. Connecting the magnets of all the indicators in series, they will form a circuit of high resistance and should be worked by a number of cells in series or by a 110-volt electric light current.

Ordinary magnets, such as are used on electric bells, will answer excellently, and five or six of them in series will offer enough resistance so that an electric light current can be used with safety. It there are only one or two magnets they should be protected from excessive currents by placing them in series with one or more incandescent lamps connected in multiple, or else a battery should be used. A switch or push button gives appropriate control. The application of these magnets will be different with different makes of indicators, and it would take too much space to describe them all. A little ingenuity will always solve the problem. It may be necessary to fasten a metal strap to some part of the pencil motion support in order to enable the magnet to actuate it. Such electro-magnetic mechanisms are sold with some indicators as a regular part of their equipment.

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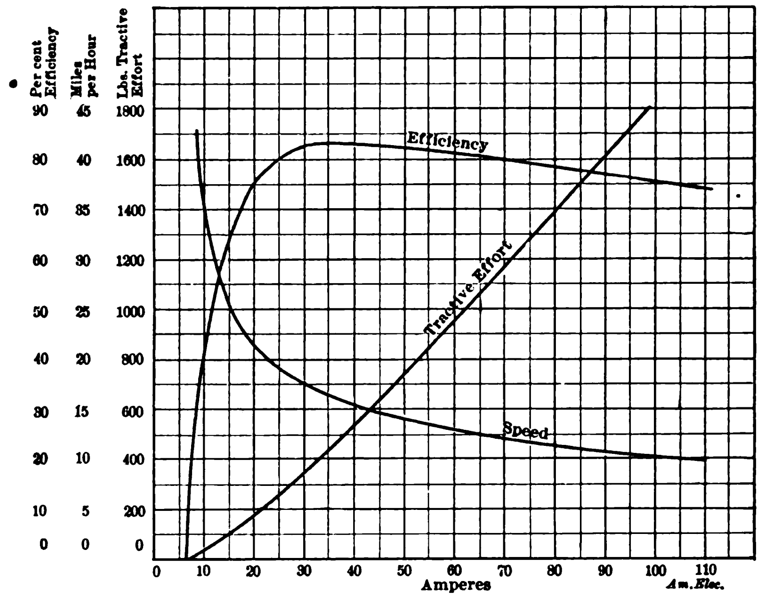
ELECTRIC RAILWAY MOTOR CURVES.

The accompanying diagram gives the speed, tractive effort and efficiency curve of a G. E.-1000-A electric railway motor, the data being as follows: Volts at motor terminals, 500; diameter of car wheel, 33 ins.; windings—armature, 4 turns, field spools, 143 turns; pinion, 17, gear, 67, ratio, 3.94; 35 HP output at 65 amperes input; speed (two-motor equipment), 25 miles per hour for a 10-ton train on a level track.

The curves are obtained by determining from tests, the values of tractive effort and speed at the various ampere inputs, plotting these values to scale and drawing the curves through the points thus obtained. The efficiency curve is drawn from values obtained by considering the actual tractive effort and speed, and comparing these with the values which would be obtained if there were no losses. The input in electrical horse-power of a motor is the product of amperes and volts input divided by 746; the mechanical horse-power output is found by multiplying the tractive effort in pounds by the speed in feet per hour and dividing by 1,980,000, the value of a horse-power hour in foot pounds. For example the G. E.-1000-A has at 65 amperes a tractive effort of 1050 lbs. and a speed of 12.5 miles per hour.



STREET RAILWAY MOTOR SPEED, TRACTIVE EFFORT AND EFFICIENCY CURVES.

$$\frac{(1050 \text{ tractive effort}) \times (12.5 \text{ miles per hour}) \times (5280 \text{ ft. per mile})}{(33{,}000 \text{ ft.lbs. per min.}) \times (60 \text{ min. in hour})} = 35 \text{ HP.}$$

The electrical horse-power input required to produce the above is

$$\frac{(65 \text{ amperes}) \times (500 \text{ volts})}{746 \text{ watts.}} = 43.5 \text{ HP.}$$

Hence the efficiency at this point is $\frac{35}{43.5}$ or 80 per cent.

The maximum efficiency of the motor is, however, higher than this as will be seen by examining the curve, which reaches 83 per cent. at 40 amperes input, when the motor is running 12 miles per hour.

The formula for horse-power given above may be conveniently reduced to the following expression:

$$\text{Horse-power} = \frac{(\text{Tractive effort, lbs.}) \times (\text{m. p. h.})}{37.5}$$

The tractive effort required to drive a train on level track in good condition, at speeds not exceeding 25 miles per hour, may be taken as 20 lbs. per ton for 10-ton train; 15 lbs. per ton for 30-ton train; 10 lbs. per ton for 60-ton train. These figures will vary considerably, depending upon speed and condition of track.

Another example will perhaps best show the practical value of the curves. Assume an ordinary car weighing 10 tons complete and equipped with two G. E.-1000-A motors. The tractive effort required to drive the car on the level will be about 20 lbs. per ton, due to track friction; that is, for a 10-ton car, 200 lbs. If the car is ascending a 4 per cent. grade, the additional effort required to lift the car up the grade will be 4 per cent of the weight of the car, or 800 lbs. The motors on a 4 per cent. grade must therefore exert a tractive effort of 1000 lbs. to overcome both the grade and the track friction, each of the motors doing one-half of the work, or 500 lbs. By referring to the curve, we find that at a tractive effort of 500 lbs. each motor requires 37 amperes input and the car is running at 15½ miles per hour.

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Transformer Explosions.

An English clergyman, in a letter to the London *Times*, complains of the danger from "transformer explosions," which, he says, are caused by water flooding transformer stations. After narrating a recent narrow escape from such a danger, he reports that, "Not long ago there was an explosion near here, on Ludgate Hill, and there have been, and, I fear, are likely to be, similar explosions. Surely it is a fearful risk allowing these transformer stations to be in public thoroughfares"!

A BIOGRAPHICAL HISTORY OF ELECTRICITY.

The announcement by Volta, published June 26, 1800, of his discovery of the principles of the voltaic cell, produced a profound sensation throughout Euope, and led to the subject being everywhere taken up for investigation. Nicholson and Carlisle, two English scientists, on May 2 of the same year decomposed water by means of an electric current produced by a Volta pile, which experiment was, says Davy, "the true origin of all done in electro-chemical science," and most probably led him to take up the work which has rendered his name so illustrious. Cruikshank the same year confirmed this discovery, and also made the further one that a current passed through a litmus solution causes acid to appear at one electrode and an alkali at another.

In 1801 Volta described in a paper to the French Institute, his "crown of cups" battery, consisting of pairs of plates of different metals, each pair being immersed in a glass of acidulated water, and the different cells thus formed united in series. The same year Cruikshank devised a form of battery in which zinc and copper plates soldered together served as partitions in a box or trough, dilute sulphuric acid filling the compartments thus formed. Dr. William Babington somewhat later improved upon this by using partitions of insulating material and attaching the plates to a strip of wood, by means of which they could be lowered into or removed from the electrolyte at will, thus first giving the voltaic battery a practical form and one which still survives in the plunge battery. It is with this form of battery that Davy performed all but the earliest of his experiments.

Sir Humphry Davy was the first to obtain fame from Volta's great discovery—not, however, as popularly supposed, by the discovery of the arc light, which he does not appear to have claimed and whose phenomena had apparently only an incidental interest to him, but as the founder of the science of electro-chemistry and through his experiments in that branch.

Sir Humphry Davy (1778-1829) was born at Penzance, Cornwall, of an old family, but in reduced circumstances. He had the advantage of no thorough school education, but fortunately at an early age was taken in hand by a Quaker, Robert Donkin, who, though a saddler by occupation, was passionately fond of scientific experimentation and had accumulated a considerable collection of philosophical apparatus. Appreciating the talent of the youth, he instructed him in the rudiments of natural science. The lad soon developed a talent for original experiment, with results in the way of explosions not always agreeable to his Quaker patron, in the garret of whose house the boy was accustomed to experiment.

After serving an uncongenial apprenticeship of three years with a surgeon, young Davy, who had acquired a considerable local reputation through his scientific gifts, accepted a position in a scientific institution at Bristol, and at once started on the work which was destined to make him famous. Contributions to scientific publications succeeded each other in rapid succession and his name quickly became well known in British scientific circles. Finally, in 1801, when twenty-three years of age, he accepted from Count Rumford a position in the Royal Institution (founded two years previously by Rumford) as "assistant lecturer of chemistry, director of the chemical laboratory and assistant editor of the Institution journals."

There are a number of points of resemblance between the careers of the Cornish natural philosopher, and the Yankee clerk, schoolmaster and royalist—Sir Benjamin Thompson of the British Baronetcy, Count Rumford of the Holy Roman Empire, and constituting with Franklin and Henry, a trio of Americans whose scientific genius has thus far stood unrivaled.

SIR HUMPHRY DAVY.

Neither had any but the most meagre school education and yet at an early age both found themselves undisputed leaders in the scientific world and welcome guests in the highest aristocratic circles. Both were married unhappily, Rumford at the age of 19 to a wealthy New England woman 14 years his senior, whose money enabled him to start on his career of fame, but whom he never saw nor cared to see after he left America three years later; and Davy, after being knighted, to a wealthy and brilliant woman of the world who apparently cared but for the glory reflected upon the name. Prosperity also affected the character of both unfavorably, Davy becoming painfully conscious of his exalted social status, while Rumford's arrogance in his latter years was the cause of much unhappiness to himself.

Davy's success at the Royal Institution was immediate. His lectures were followed by brilliant audiences and the youthful scientist became a social lion. He was elected a member of the Royal Society in 1803, became its secretary in 1806 and succeeded Sir Joseph Banks, the friend of Volta, as president in 1820. In 1812 he received the honor of knighthood and in 1820 was elevated to a baronetcy. Not the least of Davy's great claims on posterity was his discovery of Faraday and the recognition of his talent by an appointment as an assistant in the Royal Institution laboratory.

Davy's real fame rests almost entirely upon his invention of the miner's safety lamp and his work as a chemist, particularly with respect to electro-chemistry. His great electro-chemical discovery was that of the metallic basis of the so-called fixed alkalies, which he separated by electrolysis, the metals sodium and potassium being thus first isolated in his earlier work in this line. Afterwards he extended his researches to the other alkalis. Davy also gave some attention, particularly in earlier years, to the theory of the voltaic cell, and strongly supported the chemical explanation of its action as opposed to the Volta contact theory. It is erroneously stated that he was the first to show that voltaic action may be obtained from a single metal in contact with two liquids, as Volta established this fact in his controversy with Galvani.

In 1820, Davy independently discovered the magnetizing effect of the electric current on steel and iron, and a year later described how the electric arc may be deflected by a magnet. In 1823, he was called upon to prescribe a remedy for the corrosion to which the copper sheathing of ships is subject, and suggested changing the electrical condition by connecting plates of iron or zinc to the copper, thereby transferring the corrosive effect to the former. The remedy, however, brought about a condition worse than the original one, since sea growths no longer dropped off and the bottoms thus became fouled. The theory thus laid down was fifty years later applied to the protection of boilers from corrosion, the results of which, after a trial of a quarter century, being negative.

As early as 1800 Davy produced sparks between carbon rods, both in air and in water, and Tyndall states that in 1801 or 1802, he showed the "carbon light" with a battery of 150 pairs of plates, but this was probably not a sustained arc. In July, 1808, the Royal Institution was presented, for the purpose of furthering Davy's experiments, with a plunge battery consisting of 2000 pairs of zinc and copper plates, the battery costing the donors £1000. The plates were each 4 ins. square and formed 200 cells of 10 pairs each. The solution consisted of a mixture of 1168 parts water, 108 parts nitrous acid and 25 parts sulphuric acid. Davy experimented the next year on the occasion of his lectures with this battery, showing the electric arc, which phenomenon, however, he incidentally described the year before in a lecture detailing some electro-chemical experiments made with carbon in its several different forms. Davy, in fact, never appears to have claimed to be the first to produce either the carbon spark or the electric arc. His brilliant public experiments with the latter, which were witnessed by great audiences, apparently gave him that popular reputation.

LESSONS IN PRACTICAL ELECTRICITY

PRINCIPLES OF QUICK-WORKING ELECTRO-MAGNETS.

In a preceding article it has been shown that:

1°. A steady current flowing in a coil or loop is accompanied by a number of lines of force fixed by the ampere-turns (the product of the strength of current and number of turns of the coil), and by the reluctance or magnetic resistance of the path of such lines, this latter factor being dependent on the shape and dimensions of such path and its magnetic quality. In the case of a transformer, this path or *magnetic circuit* is entirely in iron; in the case of a dynamo it is partly in iron and partly in air, and in the case of an air line, entirely in air (neglecting the small part in the copper of the conductors). In a grounded circuit, such as employed in telegraphy, the earth forms one side of the loop.

2°. When the current in a coil increases or decreases, lines of force are cut in or cut out of the coil, such cutting generating an E. M. F. in the same manner as when, for example, the moving conductor of a dynamo cuts the lines in the air gap of the dynamo field. Thus, if a constant E. M. F. is introduced into a closed circuit, the lines of force accompanying the current thereby set up generate, in cutting into the circuit, an inductive E. M. F. whose current opposes that due to the impressed E. M. F., so that the latter does not at once reach its normal value; if a constant E. M. F. is withdrawn from a closed circuit, the lines of force which accompanied the current due to such E. M. F. generate, in cutting out of the circuit, an inductive E. M. F. whose current flows in the same direction as the original current, the latter therefore not ceasing abruptly, but dying out gradually.

3°. The amount of the inductive E. M. F. depends, in a given magnetic circuit and with a given number of impressed lines of force (for instance, of a magnet of given working strength), on the number of turns in the coil; and the amount of inductive current, in addition, upon the resistance of the circuit in which it flows.

The above principles are directly applicable to a number of interesting problems. For example, when one or both of the brushes of a shunt or compound dynamo is lifted, the case is presented of a sudden removal of an impressed E. M. F.; and when the circuit of an electromagnet is closed, that of the sudden introduction of an impressed E. M. F. By the use of a formula somewhat similar to that of Ohm's law, the consequence in either of the above cases can be calculated.

We will suppose the self-inductance of a magnet to be known—that is, the inductive E. M. F. in volts that would result if the current in the magnet should in one second be made to increase or decrease by one ampere. Denoting this by L, and the resistance in circuit by R, we have, for the time in which the increasing or decreasing current will reach any given fraction of its normal value, the formula

$$\text{Time in seconds} = \frac{L}{R} \times k, \qquad (1)$$

where k is a constant that may be taken from one or the other of the accompanying tables. Table I. refers to the case where an E. M. F. is removed from a circuit, and Table II. to the case of a make-circuit.

TABLE I.—VALUES OF k—E. M. F. REMOVED.

FRACTION OF NORMAL CURRENT, IN TENTHS.								
1	2	3	4	5	6	7	8	9
2.3	1.61	1.2	.91	.69	.50	.35	.22	.10

TABLE II.—VALUE OF k—E. M. F. INTRODUCED.

FRACTION OF NORMAL CURRENT, IN TENTHS.								
1	2	3	4	5	6	7	8	9
.10	.22	.35	.50	.69	.91	1.2	1.61	2.3

As an example, let us take the case of a certain 35-KW shunt dynamo having a shunt resistance of 17 ohms and a self-inductance of about 34 henrys. By applying the formula and the corresponding constants from Table I., it will be seen that if, for instance, a brush were lifted from the commutator, it would take 1.4 seconds for the shunt current to fall to half of its normal value, and 4.6 seconds for it to drop to one-tenth of normal. In other words the shunt coils act as generators of E. M. F. and current for an appreciable period after being cut-off from an impressed E. M. F., the current passing, in this case, through the shunt and exterior circuit; as the resistance of the latter is small compared with that of the shunt, it need not enter into the formula.

Since in the case of electromagnets, the armature is released by the circuit being broken, the value of R in the formula becomes infinite (unless there is a following spark) and the time of release is infinitely small, considering inductance alone. In making circuit, however, the case is different, and corresponds to that of an impressed E. M. F. suddenly introduced in the circuit, and which can only establish its current gradually.

Let us now see what practical considerations we can deduce from the above principles with respect to the quick-working electromagnets. We will assume, in the first place, that we have a magnet which we know to be of the proper strength for our purpose when supplied with a given current; and, furthermore, that we know the number of turns in the coil. No matter what changes are made in the windings and current, if the ampere-turns remain the same, the magnet will always have the same strength.

As we only desire comparative results, formula (1) may, under the above assumptions, be simplified for this purpose to the form $T = \frac{L}{R}$, in which case the time, T, corresponds to a value of current on make-circuit of about $\frac{5}{8}$ of the normal value.

Suppose that each spool of the magnet has a resistance of 20 ohms and 1000 turns of wire, and that a current of $\frac{1}{20}$ ampere will give the magnet sufficient strength for the purpose for which it is intended. The number of ampere turns is, therefore, 50 for each spool. Also assume that the inductance of each leg of the magnet is 2 henrys, and that the resistance in the exterior circuit is 5 ohms and non-inductive—the resistance, for example, of a primary battery supplying current.

1°. The two spools are in series (Fig. 1).

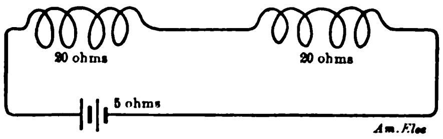

FIG. 1.—MAGNET SPOOLS IN SERIES.

In this case T becomes $4 \div 45 = .088$. Introducing now a non-inductive resistance in circuit of 20 ohms (Fig. 2), T becomes $4 \div 65 = .061$, or the magnet is made quicker working through introducing resistance.

2°. The two spools are in parallel (Fig. 3).

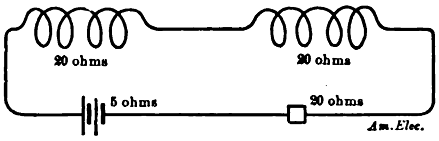

FIG. 2.—MAGNET SPOOL IN SERIES, 20 OHMS ADDED TO CIRCUIT.

In this case, in order for the magnets to retain the same strength, the current will have to be doubled, and becomes $\frac{1}{10}$ ampere in the exterior circuit. As the two coils are now in parallel, their inductive E. M. Fs. act as in the case of two voltaic cells in parallel, and only the value of one coil, or 2 henrys, enters into the formula. The resistance of the two spools in parallel becomes only half of one spool or 10 ohms. The value of T is, therefore, $2 \div 15 = .13$, or the magnet has been made slower-working by coupling in parallel. Introducing now 20 ohms (Fig. 4) of non-inductive resistance in the exterior circuit, T becomes $2 \div 35 = .056$, or the magnet is quicker-working than in any of the cases thus far considered.

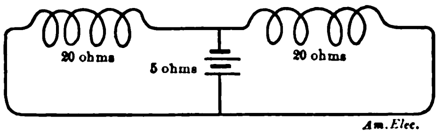

FIG. 3.—MAGNET SPOOLS IN PARALLEL.

Let us now strip one-half the wire off each spool and determine the result. The consequence of this will be that, to retain the proper strength, twice the current must be used, or $\frac{1}{10}$ ampere when the spools are in series, and $\frac{1}{5}$ when in parallel. Since now the lines of force of the magnet (which, since the ampere-turns remain the same, are unchanged in number) have to cut through only half the number of turns as before, the inductive E. M. F. generated, the inductance

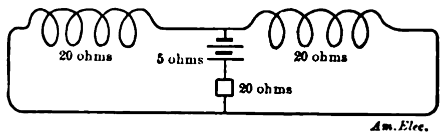

FIG. 4.—MAGNET SPOOLS IN PARALLEL, 20 OHMS ADDED.

will be but half as great, or 1 henry. We will now repeat the above calculations with the new data.

3°. The two spools are in series (Fig. 5). The inductance being $1 + 1 = 2$, and the resistance $10 + 10 + 5 = 25$ ohms, T becomes $2 \div 25 = .08$, or more than in 1°. With 20 ohms introduced (Fig. 6), we get $2. \div 45 = .044$, or less than in either 1° or 2°.

4°. The two spools are in parallel. The inductance being 1 and the resistance $10 \div 2$ and 5, or 10 ohms, we have $T = .1$, or more than when in series. With the 20 ohms exterior resistance, T becomes $1 \div 30 = .033$, or less than in any other case considered.

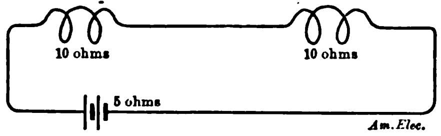

FIG. 5.—MAGNET SPOOLS, HALF WINDING IN SERIES.

From the above it will be seen that the best winding to give a quick-working magnet depends upon the relation between the exterior and magnet resistances, but that in any case a magnet may be made quicker-working by introducing in circuit non-inductive resistance, the E. M. F. in circuit being correspondingly increased that the current may be unchanged. It will also be seen that if the external resistance is negligible in comparison with the resistance of the magnets, no change of connection or reduction of turns will make the magnet slower-working.

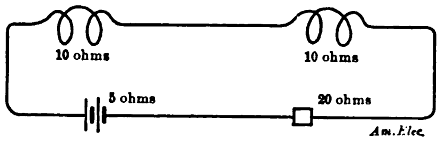

FIG. 6.—MAGNET SPOOLS, HALF WINDING, IN SERIES, 20 OHMS ADDED.

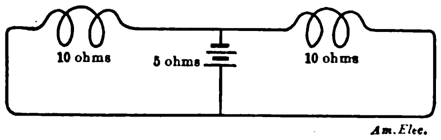

FIG. 7.—MAGNET SPOOLS, HALF WINDING, IN PARALLEL.

By assigning different values in the cases above calculated, it will be found that a magnet will be quicker working if connected in series, *when the resistance of one of its spools is greater than that of the external circuit;* or in parallel, if such resistance is *less* than that of the *external* circuit. In any case, it will be instructive to give different values to the quantities in the several cases, and to calculate the actual time required for the current to reach some certain fraction of its value, as determined by the constant taken from Table II. If the inductance data of any magnet are at hand, that value should be taken which corresponds to the armature drawn back.

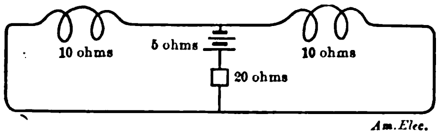

FIG. 8.—MAGNET SPOOLS, HALF WINDING, 20 OHMS ADDED.

The conclusions that may be drawn from the above are, that the windings of quick-working magnets should have the smallest possible number of turns, which implies that the working current should be the largest practically possible. To find the number of turns, place a trial winding of a known number of turns on the cores and find the value of current which gives the magnet the necessary pulling strength, and thus obtain the ampere turns. Then select the largest practicable value of current that can be used, and divide the ampere turns by the value of this current, which will give the number of turns. The trial winding should be connected in series and also the final winding; if the resistance of one spool of the latter is less than the external resistance, put sufficient non-inductive resistance in the latter circuit to bring about the opposite results.

To complete the main principles applying in the design of quick-working magnets, eddy currents and hysteresis should be considered. Eddy currents are similar to the secondary current of a transformer, from which it follows that their lines of force act against those of the impressed current, and therefore make a magnet slower-working. To obviate this effect, the core should be laminated or made of fine soft iron wires.

If hysteresis, as is sometimes said, also affects the quick working of magnets, the amount may be reduced by selecting iron of good hysteretic quality, and, possibly by, reducing its weight. To accomplish the latter, since the cross-section of the core is fixed, the length must therefore be shortened. As experience has appeared to show that short magnets are best for quick-working purposes, this indication should be followed even if not true with respect to hysteresis, since no bad effect can thereby be introduced.

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Early Vicissitudes of the Telegraph.

The Engineer-in-Chief of the Belgian Telegraph department in a recent address at the jubilee of the Belgian telegraph service related some interesting anecdotes concerning the early history of the telegraph. When Francis Ronald—afterwards Sir Francis—invited, in 1816, a high English government official to witness some experiments with his static electric telegraph, he received a reply as follows: "Mr. Barrow begs to inform Mr. Ronald that telegraphs of any kind are quite useless, and that no other than the one in use will be adopted"—the one in use being the Chappé semaphore! When a plan for a semaphore telegraph was submitted to the Belgian government in 1840, it was rejected on the ground that its use would encourage stock exchange gambling, while "Commerce has no need of it, the restricted limits of the country, and the increased facilities offered by the railways, moreover, render its establishment useless." When the bill appropriating money for the trial of the Morse electromagnetic telegraph was passed by Congress in 1843, the assistant to the Postmaster-General, Hon. John A. Bryan, wrote as follows to a member of Congress: "There is an abominable plot to ruin me. Would you believe, my chief has associated me with Morse's mad schemes, by intrusting me with the control of the $30,000 voted."

Letters from Practical Men

Wimshurst Influence Machine.

I have just completed a Wimshurst machine similar to that described in the November number of the AMERICAN ELECTRICIAN, and I find that it will give a torrent of one-half-inch sparks without a condenser and that by using a mica flat condenser I have readily attained three inches. Inasmuch as the article states a two-inch spark, may I ask whether a condenser was supposed to be used in connection with the machine or not? If the condenser was to be used, the estimate was moderate, and if not it was far too large, or else I have made some mistake in construction. I have a specially made Crookes tube which the machine excites brilliantly, but I can obtain no X-rays. This I account for because I have simply terminals of straight wire and no reflector plate on the anode. The machine performs with ease all of the experiments common to any school physics. STATIC.

[The machine was intended to be used with a condenser in order to obtain a two-inch spark. It was an error of omission in the article that gave the other impression.—Ed.

◆

A Novel Way to True Commutators.

If you have a rough commutator that makes the brushes spark and you do not want to take the armature out to turn the commutator off, get a piece of a grindstone, file off the lumps and then take the stone and press down on the commutator firmly. Be careful not to move it until a circle is worn in the stone, then work it back and forth from end to end of the commutator and continue grinding until the surface is smooth. Finally finish with No. 1 sandpaper and oil. *Never use emery paper.* You will have as the result of the above operation a commutator smoother than you can turn it in a lathe. T. L. LYNCH.

◆

A Power House Accident.

I happened to be standing in a position in a street railway generating station one morning where I could see the switchboard, dynamo and engine all at one glance, when, without any warning, the entire machinery shut down, the hand of the ammeters standing at zero. There had been no sparking at the dynamo brushes, as there would have been in case of a short circuit. I closed the throttle and ran into the the fire room to see if any of the firemen had closed a valve in the steam pipe, but found them reading newspapers. I then went back and tried to start the engine, but it would barely turn over. Next I took off the steam chest cover and found the valve all right. Taking out the valve, and opening the throtle, a full head of steam was found at the engine. Putting the valve and cover back, the cylinder head was taken off and the cylinder found to be badly cut. The day engineer said the night shift had fitted a new set of rings to the piston (single rings), and that he had a great deal of trouble getting the piston in the cylinder. I had the piston moved to the end of the stroke and the cylinder mopped with powdered graphite and oil. Upon replacing the cylinder head and turning on steam, the engine started up at once and ran all right. The trouble was that the piston rings were too long, and when the engineer forced the piston in, the rings jarred and started cutting.

H. S. Hall.

◆

The Care of Commutators.

A rapidly spreading fallacy concerning the treatment of commutators is the theory that dressing them down with fine emery cloth and then rubbing them with an oily rag is the most efficacious means of keeping them in good condition. If "good condition" means the ability to furnish without notice a pyrotechnical display appropriate for the Fourth of July, then the emery and oil are all right, but I imagine no engineer who has been unwary enough to try it once ever repeated the experiment.

The best practice that the writer was ever able to discover was the use of 00 sandpaper, tacked to a piece of board exactly the width of the commutator face; this should be pressed on the commutator for half a minute each time a machine is started (or once every 24 hours in the case of continuously-operated machines), with the brushes raised; the commutator should then be wiped thoroughly with an absolutely dry rag to remove the particles, cut off by the sand paper, which stick to the insulation between the segments. When the application of a clean bristle brush (a common flat paint brush) fails to show evidence of loose particles, then the commutator should be touched with a slightly oily but otherwise clean rag, and again wiped with a dry, clean rag. Then, and not until then, the brushes may be put down and the machine put in circuit.

The use of dirty, greasy cotton waste or rags for wiping a commutator is reprehensible, and the idea that emery cloth is beneficial is most absurd; the particles of emery, with particles of copper, become embedded in the insulating strips and not only cut the brushes out and cause vicious sparking, but in a short time attain such proportions as to form a disastrous short circuit. The combination of oil with the emery simply aggravates the resultant troubles enormously, forming a sort of paste which accumulates much more rapidly than the dry emery and copper particles and makes a more substantial bridge across from bar to bar.

The practice above recommended effectually removes the small brush cuttings which inevitably attend the use of copper brushes, and the burned particles of carbon which result from the use of carbon brushes; the commutator is, therefore, kept in clean condition, and the operation of the machine is greatly improved, the infinitesimal bits of copper, burnt carbon and insulation being removed before they can accumulate sufficiently to cause sparking and the cutting of both commutator and brushes.

Cecil P. Poole.

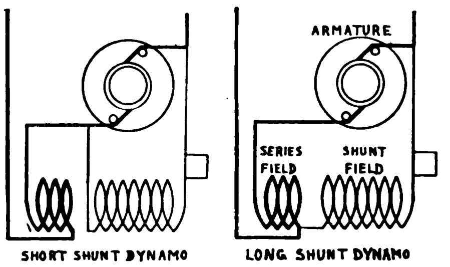
ELECTRICAL CATECHISM

79. Why are machines overcompounded?

In order to keep the voltage constant at some point at a distance from the dynamo. The machine is adjusted so that the series coil strengthens the field and thereby raises the voltage enough to compensate for that lost on the line, as well as for that lost in the machine.

80. What is meant by "short-shunt" compound dynamos?

In short-shunt dynamos, one terminal of the shunt field coil is connected between the armature and the series coil, as indicated in Fig. 1.



FIGS. 1 AND 2.

81. What is meant by "long-shunt" compound dynamos?

In long-shunt dynamos, the terminals of the shunt field coil are connected to the outside terminals of the machine, as indicated in Fig. 2.

82. What are the relative advantages of long-shunt and short-shunt dynamos?

Practically there is very little difference between them since the drop in voltage through the series coil is very small. If the machine is to give constant voltage at its terminals or at the bus-bars at the switchboard, it is somewhat simpler to calculate the number of turns of wire necessary for the series coil if the shunt coil is connected with the terminals and so gets a constant current. Again, when several machines are operated in multiple, if they are connected long-shunt, the shunt field coils may be connected directly to the bus-bars at the switchboard and so the field of one machine may be magnetized by those already running. This enables one to get a machine ready for service more quickly than when it must pick up by itself. It also insures that the polarity of the fresh machine is not reversed.

83. How are compound dynamos coupled to work in multiple?

Compound machines act very much like shunt machines and in general the explanations in the Catechism for October (American Electrician, October, 1896, page 216) hold good for compound machines. With compound machines it is necessary to have an extra bus-bar or conductor making a common connection for all the machines between the series coils and the armatures, as indicated in Fig. 3.

84. Why is the equalizer necessary with compound machines?

It is to help divide the load more evenly among the different machines. If the machines were coupled directly in parallel, the current from each armature would go through its own series field coil. Thus it might happen that when the load was increased, if one machine was a little more sensitive than the others, it would take more than its fair share of the load; this extra current through its series coil would strengthen its field and cause it to generate still more and more current until its belt would slip or its fuse would blow and open the circuit. The load would thus fail to divide equally and the operator would have to adjust the rheostats and brushes.

85. How does the equalizer help balance the load?

By coupling all of the machines to the equalizer so that all have a common connection between the armature and the series coils, the currents from all the armatures unite and then divide among the different series coils. By this means, if one armature tends to deliver more than its proportion of the whole current, it strengthens the current in the series coils of all the machines and not its own alone. On the other hand if one machine tends to shirk its load, some of the current from the other machines goes through its series coil and strengthens its field so that it delivers more current.

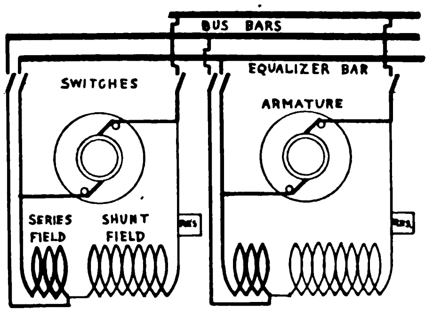


FIG. 3.—PARALLEL EQUALIZER CONNECTIONS.

86. How large conductors should be used for the equalizer?

Strictly the equalizer bar or bus should have no resistance, but since it is impossible to avoid all resistance this should be as small as practicible. Sometimes the equalizer connections for all the dynamos are run to a common point, so that there is no equalizer bus. The rule for determining the sizes of the equalizer connections is to make the resistance from the equalizer bar through the series field coil to the bus-bar such that each series coil shall carry the same share of the load, that its armature should carry. In practice it is frequently necessary to connect an adjustable resistance in parallel or in series with the series coil.

Do the above directions apply to alternators for supplying incandescent lamps?

No. All the directions and explanations given in this catechism up to this point have referred to continuous current machines. Alternators will be taken up after studying compound-wound continuous-current dynamos.

QUERIES AND ANSWERS

Why are modern slotted armatures built with an odd number of slots and commutator segments? J. C.

Because the winding is of the two-circuit kind, known as wave winding. (See Fig. 8 in the article on "Modern Armature Windings," which appeared in our August issue.)

What is the principle of the three-wire alternating current transformer, and is it as practical and efficient as the two-wire type? D. S.

A three-wire transformer is an ordinary transformer with a third wire led from the middle point of the secondary winding; the former is therefore just as practical and efficient as the latter.

Can two T.-H. arc machines be coupled in series? In this case will each coil be subjected to double the voltage? E. F. G.

Any number of arc machines may be coupled in series; each machine will operate precisely as if alone in circuit, and have no greater voltage in its coils. There will, however, be more danger to the insulation if the circuit is suddenly opened, on account of the greater inductance.

I can get a shock from the pole pieces, shaft and commutator of my dynamo when in operation; what test should I apply to find the ground? T. J. P.

Test with a magneto both when the dynamo is not running and when in operation. The magneto should not ring through over 5000 ohms, as the ground may not be sufficient to cause trouble, but yet give a shock. If a ground is made evident, test separately the fields, distributing circuit, armature and binding post and brush connections.

What is the magnetic density per square inch in modern armature and field magnet cores? F. W.

The density in continuous current armature cores ranges from 80,000 to 95,000 lines per square inch; in alternator armature cores it ranges from 33,000 to 38,000 lines. In cast iron magnet cores the density is from 38,000 to 45,000 lines; wrought iron and cast steel cores are worked at densities of from 65,000 to 80,000 lines per square inch.

How can I make a converter to transform a 35-ampere 35-volt direct current to a 110-volt direct current? R. L.

Such a converter would either be a 35-volt 35-ampere motor running a 110 volt, one kilowatt dynamo, or a machine having the two windings on the same armature with a single field—called a dynamotor or rotary transformer. It would be much cheaper to buy such a machine than to make it. They are largely used for telegraphic work, and one American firm makes a specialty of their manufacture.

What is the charging current of a storage cell, and how can I tell when it is fully charged? C. H. P.

The charging current depends upon the area of the positive plates, counting both sides, and should be about 1 ampere per 30 square inches of positive plate surface. The capacity is about 5 or 6 ampere-hours per pound of lead plates. A cell is fully charged when the acid "boils." As soon as boiling commences, reduce the charge, and cease charging when the electrolyte continues to "boil" with a small charge. See article by Maurice Barnett in November issue.

1°. Would not a glass tube do as well as one of rubber for the induction coil described in the May number? 2°. Is it not preferable to have an induction coil immersed in oil; if so, what oil would you recommend? N. T. L.

1°. Glass will do as well, but it is too fragile. 2°. If oil is used, a light paraffine oil is preferable. Recent experiments with induction coils seem to show that the space between the primary and secondary coils may be greatly increased. In one case the secondary wire was reduced in the center of its bobbins to make room for one-half inch extra paraffine insulation, and yet the spark was largely increased.

What is the formula for determining the current that will melt copper wire? R. C.

Hospitalier gives the formula $C = 80\, d^{\frac{3}{2}}$, where the diameter, d, is expressed in millimeters. This reduces to $C = .325\, d^{\frac{3}{2}}$ when the diameter is expressed in mils or thousandths of an inch. This formula gives for the melting currents of Nos. 10, 16, 22, 24 and 30 copper wire, 333, 117, 41, 29 and 12 amperes, respectively. This formula cannot be relied upon for fuses, as it does not take into consideration the cooling effect of the terminals. For copper fuses the melting point should be determined for the style of block used, and for, say, one or two sizes of wire, combinations of which can then be used for larger currents.

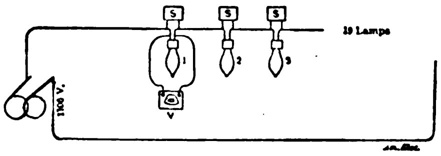
How can a watch be demagnetized? T. J. P.

Suspend the watch from a cord and twist the latter so that it will cause the watch to be rapidly rotated when released. When rotating approach the watch to an electromagnet or to the gap of a continuous current dynamo; then slowly withdraw it so as to be beyond magnetic influence when rotation ceases. If an alternating current is available, wind wire about a cardboard cylinder of sufficient diameter to admit the watch and three or four inches high, the depth of the turns tapering from the bottom of the cylinder to the top. Connect an incandescent lamp in series with the coil, lower the watch by a cord into the cylinder and then slowly withdraw it.

Does applying a certain E. M. F. to a conductor having one end insulated raise the whole of the conductor to that E. M. F. irrespective of its length? O. F. L.

The entire conductor will be raised to the same potential as that of the E. M. F. connection. If we assume the earth to be at zero potential, then if the other side of the seat of E. M. F. is connected to the earth, the value of the potential will be expressed by the value of the E. M. F. Properly speaking the seat of E. M. F. is the place where it is generated—in the armature coils of a dynamo or at one of the plates of a voltaic battery. An analogy to explain the difference between E. M. F. and potential in a circuit through which a current is flowing, may be found in a centrifugal pump circulating water in a closed circuit. Here the difference of pressure between the pump inlet and outlet (or the pressure generated in the pump) would correspond to the E. M. F., and the pressure shown by a gauge placed at any point of the circuit would be the hydraulic potential of that point. If the pipe offered no resistance to the flow of the water, the potential at every point in it would be the same; similarly, if the wire of an electric circuit had no resistance, the potential at every point of it would be the same, and there would consequently be in the wire no difference of potential, or no E. M. F., or, more properly speaking, no drop of potential.

I have 22 50-volt, 25-CP incandescent lights in series on a 1100-volt, 125-cycle alternator, each lamp being shunted by an inductance—a Westinghouse shunt coil—which take the place of the lamp when the latter burns out, its "choking" E. M. F. being equivalent to the voltage of the lamp. (*a*) The voltmeter reading under normal circumstances is 49. (*b*) With the voltmeter on 1 and the lamp 2 removed, the reading is 47 volts. (*c*) With the voltmeter on 1 and lamp 1 removed, the reading is over 150 volts, the limit of the instrument being 150. Since under normal conditions the voltage is 49, the drop in the line is 22 volts. In the case (*b*), therefore, the choking effect of the shunt of No. 2 on the line is 49 + 2 × 21 = 91 volts, while in case (*c*) it registers over 150 volts. How can these discrepancies be explained? W. B. C.



The magnetic circuit of the shunt coil in this case is not normally saturated. Consequently, when the entire line current is forced through it, an E. M. F., is induced which is much greater than that under normal conditions when a mere fraction of the line current passes through. The E. M. F. measured at the shunt in case (*c*) is not in phase with that of the line, and therefore its effect on the line is less than represented by its numerical value, depending upon the angle of phase difference.

What is phase difference, and how does it enter into the generation of alternating currents? G. M. K.

A simple illustration of difference of phase is offered by, say, three men walking in the same direction about a circular track and at the same rate of speed. If the three men are equally distant from each other, they will pass a given point at equal intervals behind (or in advance of) each other, their difference of phase with respect to that point being, therefore, one-third of 360 degs. or 120 degs. Looking at the application in the generation of alternating currents, the phase difference of two or three-phased E. M. Fs. or currents when expressed in degrees, is the angular distance between corresponding armature wires of the two or three generating circuits, with reference to a bipolar field. This is 90 degs. for the two-phased system (sometimes called the "quarter-phase" system) and 120 degs. for the three-phased system. In a two-phased bipolar machine, for instance, when a wire of one circuit is in the gap, the corresponding wire of the other circuit is in the strongest part of the field. Therefore, when the E. M. F. in the first wire is zero, that in the second is a maximum, and the two are said to differ 90 degs. in phase. As the armature continues to revolve, the strength of current changes in both wires, but as either wire passes a given point in the field, it will there have the same current the other wire had when at the same point. In other words, while during a revolution each will generate the same current, at any given instant the current will differ in direction or n value—that is—differ in phase.

NEW Apparatus AND Appliances.

ALTERNATING CURRENT SEWING MACHINE MOTOR.

In the description printed in these columns last month of the new and interesting design of sewing machine motor there illustrated, it should have been added that the machine is known as the Kent motor, and is manufactured by the Kent Electrical Manufacturing Company, 37 Hermon Street, Worcester, Mass.

PACKED CARD RHEOSTATS.

A new line of rheostats has recently been placed on the market, known as packed card rheostats, the name being derived from their method of construction.

To form a unit resistance card, a wire ribbon of German silver of definite length and size is wound upon a tube of asbestos formed on a steel mandrel and which, when the mandrel is withdrawn, is flattened and creased in a press to give it the card shape. In building the rheostat any desired number of these unit cards are placed side by side and separated by asbestos. The whole is then clamped by suitable end plates and bolts and forms a resistance section. To increase the radiating capacity of the resistance section iron plates are inserted between cards and project beyond the general surface of the section. The same general structure is followed in all rheostats and motor starting boxes of the packed card type, the cross section and length of the resistance wire or ribbon alone being varied. The use of the flat card allows a very large resistance capacity to be placed in a small space, while the creases hold the coils firmly against displacement.

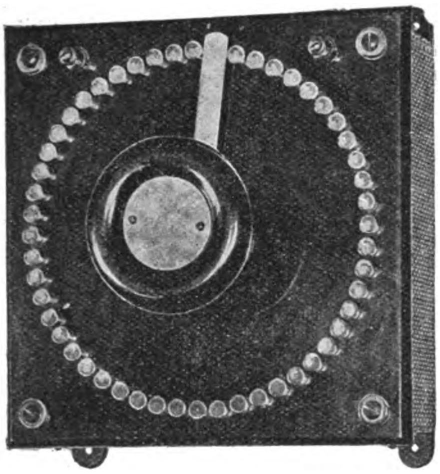


FIG. 1.—STANDARD GENERATOR FIELD, D. C. RHEOSTAT.

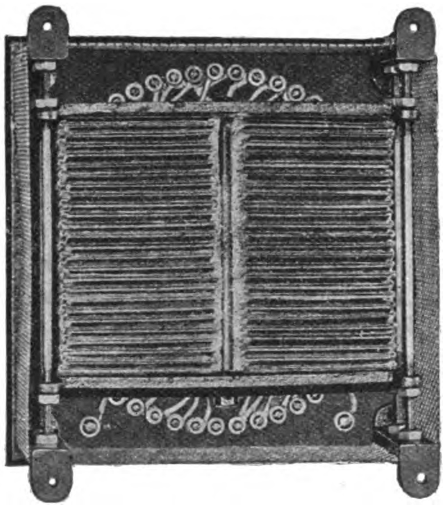


FIG. 2.—REAR VIEW OF STANDARD GENERATOR FIELD, D. C. RHEOSTAT.

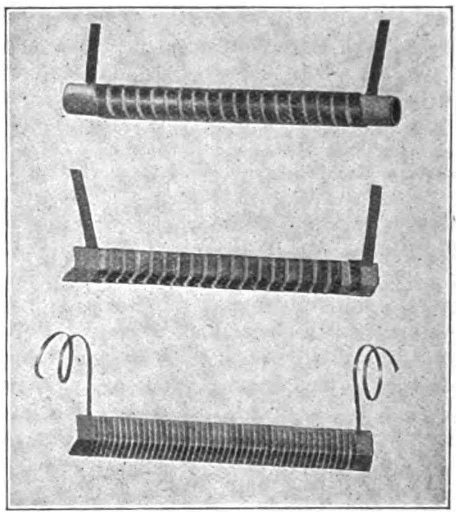


FIG. 3.—WOUND TUBE AND PRESSED CARDS.

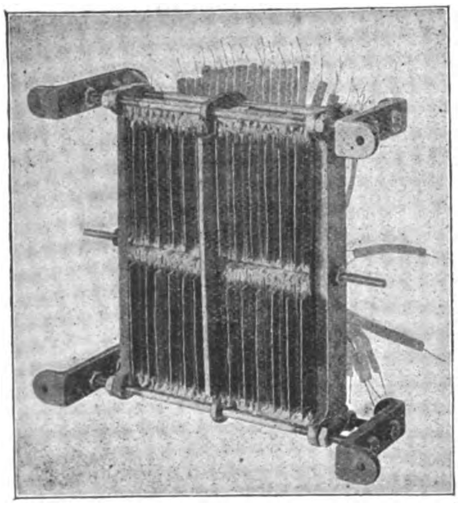


FIG. 4.—SHOWING IRON PLATES BETWEEN CARDS.

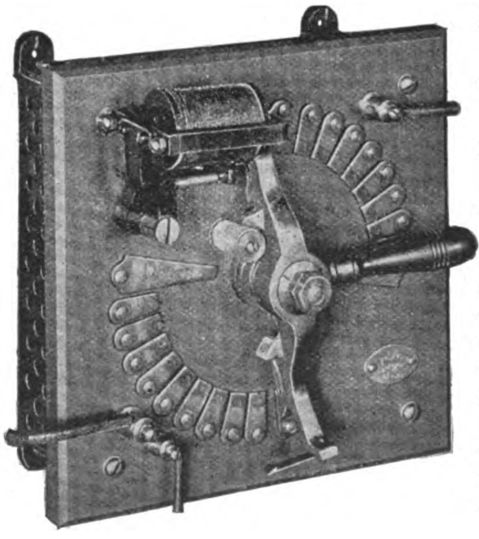


FIG. 5.—STANDARD MOTOR WIRING, D. C. RHEOSTAT AND AUTOMATIC SWITCH.

The advantages of this method of rheostat construction are absence of combustible material; exceedingly large radiating surface for weight and bulk of resistance material; chance of short circuit or similar troubles eliminated by complete insulation of the resistance; easy replacement of damaged cards when necessary; ability of resistance to withstand overloads; it expands and contracts freely, and as the burning of one card only impairs the use of the apparatus until a new one can be inserted, or the old one be short circuited, no overload can destroy the rheostat.

The switches used with these rheostats differ with the use to which the device is put. The steps of the field rheostat switches vary in number from 25 to 50—the majority having 50 steps to provide for close regulation—and are mounted on 10-in. × 10-in. slate bases. The motor switches, with the exception of the three largest sizes, are also mounted on slate bases, the number of steps up to and including 10 HP being the same.

The starting rheostats for motors are built with or without an automatic release switch, the standard switch being automatic. This automatic release is essential to the successful operation of isolated motors, for if the current stops, the circuit is automatically opened and remains open until closed by hand. The motor armature is thus protected against injury by any sudden rush of current, if the supply of current in the mains be suddenly thrown on after having been cut off, as sometime happens from street mains. With the automatic switch the starting resistance is all in as soon as the motor is shut down from any cause.

The generator field rheostats are constructed to be mounted either in front or behind the switchboard, and the motor starting rheostats on the front of the switchboard only. The former are built for 500, 250 and 125-volt circuits, the latter for 110, 220 and 500-volt circuits; those for 110 and 220 volts being adapted for use also on 125 and 250 volts.

The above line of rheostats is manufactured by the General Electric Company.

COMMERCIAL MOTORS AND GENERATORS.

A new type of generator and motor recently placed on the market is illustrated in Figs. 1 and 2. The machines are built for both low and moderate speed, and a high efficiency is claimed, due to a low reluctance of the air gap, low hysteresis loss and small expenditure of energy in the field, the two latter resulting from the high electrical quality of the iron used.

The field frame is of annealed cast steel of special quality, and the coils are form-wound and taped, the field cores being made round in order to require the smallest possible amount of wire, and thereby insure the highest efficiency. The strength of the field is such as to obviate any sparking with change of load. The construction of the machine is such that to remove the armature or dismantle the machine, no loosening of connections is necessary, the yoke arms supporting all terminal boards and connections.

The armature is of the ring type, with wires on the surface where they are exposed to the cooling action of the air. The ring is open at both ends, permitting an unobstructed circulation of air through the middle of the core, and thus cooling every wire on the armature as well as the core itself. The brushes, which are carbon, feed automatically and do not need to be reset as they wear down.

In Fig. 3 is shown an electric pump, made by the same firm, which is particularly applicable for use in office buildings and residences to supply reservoir tanks where the head of water is low. A special feature is the absence of gears, the motor being connected to the pump entirely by belt, thus doing away with the annoying sound which is unavoidable even with the best cut gearing. The motor is a special low-speed machine, placed on the same bed-plate with the pump and connected to it by means of an endless belt running over an idler. A spring acts upon this idler to keep a constant tension of the belt and prevent slippage.

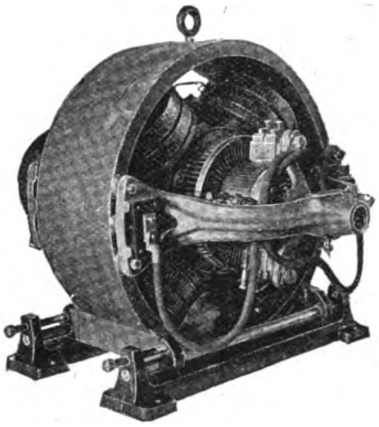


FIG. 1.—SLOW SPEED DYNAMO AND MOTOR.

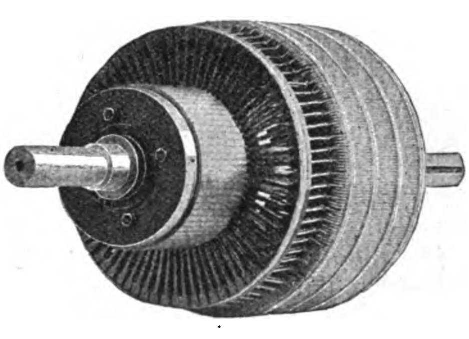


FIG. 2.—ARMATURE OF SLOW SPEED DYNAMO AND MOTOR.

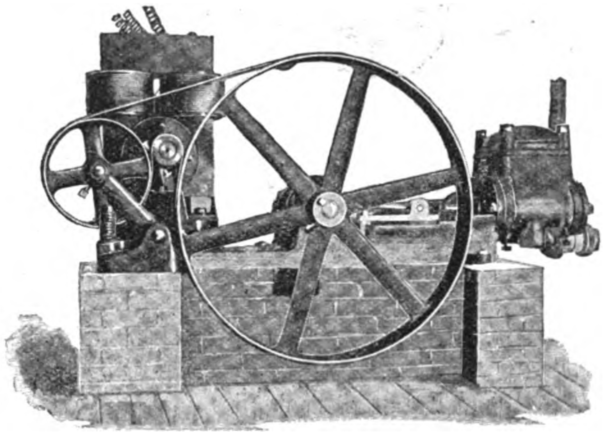


FIG 3.—ELECTRIC PUMP.

The above machines are made by the Commercial Electric Company, Indianapolis. Ind.

BROOKLYN BRIDGE MOTOR CARS.

On Nov. 30 twelve motor cars were put into service on the Brooklyn Bridge for switching purposes and night service. Fourteen are now in use and six more car equipments will be put into service as soon as completed.

The motor cars do not differ outwardly from the regular cars, except that the platforms are three inches longer. The length of the car is forty-five feet over all and weighs about twelve tons more than the ordinary car. The total weight with the motors is about thirty tons.

The trucks are from the shops of the McGuire Manufacturing Company, of Chicago, and have been especially designed for this work. In these trucks the draft of the train is taken directly on the journal boxes, instead of through a swinging bolster, the entire top frame having sufficient lateral motion to cushion on curves. The weight of each truck is 1000 lbs.

The general character of the electrical equipment is similar to that in use on the Metropolitan West Side and Lake Street Elevated Electric Railroads in Chicago, and on the electrically operated divisions of the New York, New Haven & Hartford Railroad. The equipment of each motor car consists of four G. E.-50 motors and two K-14 series-parallel controllers—motors and controllers being both especially designed to meet the peculiar requirements of Bridge traffic. The motors have the usual characteristics of all General Electric railway motors, and are spring suspended; the two forward ones are provided with a small roller in the front upon which the cable can run and thus prevent injury to cable and motor. The illustration shows one truck of a motor car with a controller and gives a fair idea of the compactness of the equipment. Each motor car has each truck similarly equipped.

The series-parallel controllers embody the magnetic blow-out principle. In their operation, when the current is shut off, resistance is first introduced and the potential at the motor reduced before the circuit is broken. When the circuit is broken the arc is immediately blown out and the contacts do not suffer, the blow-out serving to chill the arc by spreading it over the surface of the breaking points instead of confining the root of the arc to its point of origin and consuming it.

The total number of notches is 13, six of the resistance points being in series and five in parallel. The reversing switch is, of course, arranged for four motors. The handle is interlocking and cannot be moved unless the controller handle points to the off position.

The resistances suspended beneath the cars are twelve in number. They are of the packed ribbon type set in open iron boxes. Beneath each platform is an automatic circuit breaker, which is set at 800 amperes; should the current exceed this, a latch is tripped by the action of a solenoid, and the contacts in the device are instantly separated, breaking the circuit. Additional protection is provided by cut-outs also embodying the magnetic blow-out principle, whereby the arc formed at the disruption of the fuse is magnetically extinguished.

The current is taken from a third rail in a manner similar to that used on the electric roads in Chicago. This third rail runs on the outside of the service track and parallel with it across the Bridge, and at all crossings and switches is about one foot from the outside rail. The third rail used is the ordinary T rail bonded with two No. 0000 bonds. They are laid on insulators, one of which is set every fifth tie. These insulators are square pyramidical pieces of vitrified clay with a single petticoat, and are supported on iron pins fastened to the tie. The top of the pyramid carries two jaws, which grip the foot of the third rail and are screwed up by means of a bolt and nut. For the return, the service rails are also bonded with No. 0000 bonds. Between the journal boxes of each truck and on each side of it is an oak beam, from the center of which depends one of the contact shoes. These shoes are slung loosely from jointed and slotted hangers, and having an easy up-and-down motion as well as the ability to take any angle within a wide range, follow the surface of the rail at all times and make perfect contact. The shoes are of cast iron about 12 ins. long by 10 ins. wide and ½ in. thick. Each weighs about 10 lbs., and is wide enough to slide over all breaks on the third rail at all switches and crossings, one shoe being always in contact. An insulated flexible cable connects the shoe to the motor.

The electrically equipped cars are known as the motor cars, and one is allotted to each train, forming part of it and carrying its share of the passengers. Its function is similar to that performed by the switching locomotives. The train empties at the terminal, the motor car draws or pushes it from the incoming platform to the tail track and thence to the outgoing platform. It then moves the train over the tilting sheaves so that the grips on the other three cars may seize the cable, when the current is shut off and the cable performs its ordinary functions. Under the conditions of the contract, the power of the four motors must be sufficient to propel the fully loaded train, weighing 120 tons, across the Bridge at the speed of the cable, 11.3 miles an hour, in case of breakdown of the cable. With the motors, the heaviest Bridge trains are readily hauled up the 3.78 grade, and so far as they are concerned, comply fully with the conditions. During the early morning hours the motor cars will handle the entire traffic of the Bridge after the cable has stopped running.

The motors will also help heavily loaded trains up the grades and thus keep the grips from slipping on the cable. The substitution of the motor car eliminates one set of grips, while adding about 12 tons to the weight, and three grips are not always sufficient to handle trains which may be heavily loaded. As soon as the second set of tracks is ready and the additional cable running, it is expected that the headway will be reduced from 90 to 45 seconds.

The efficiency of the electric system in an emergency was tested on the evening of Dec. 2, 1896, when the operation of the cable was accidentally suspended. The rush homeward from New York to Brooklyn had already set in, and the entire operation of the Bridge for some half hour was thrown upon the motor cars. According to the Bridge authorities the traffic was carried on without any appreciable loss in headway.

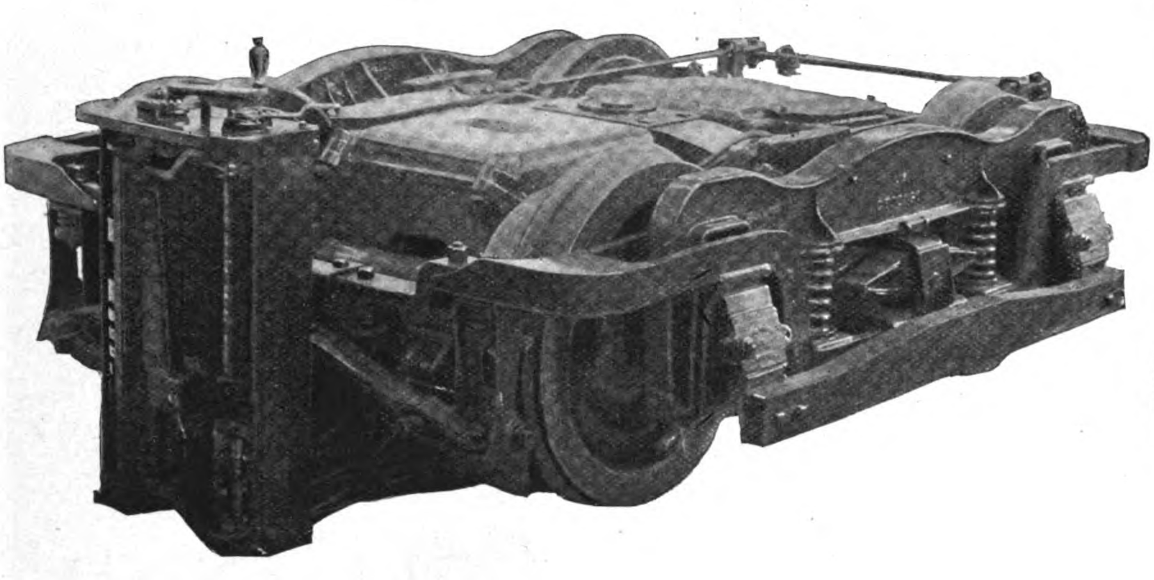
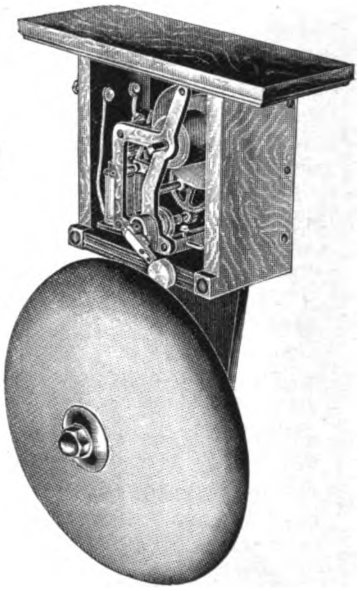


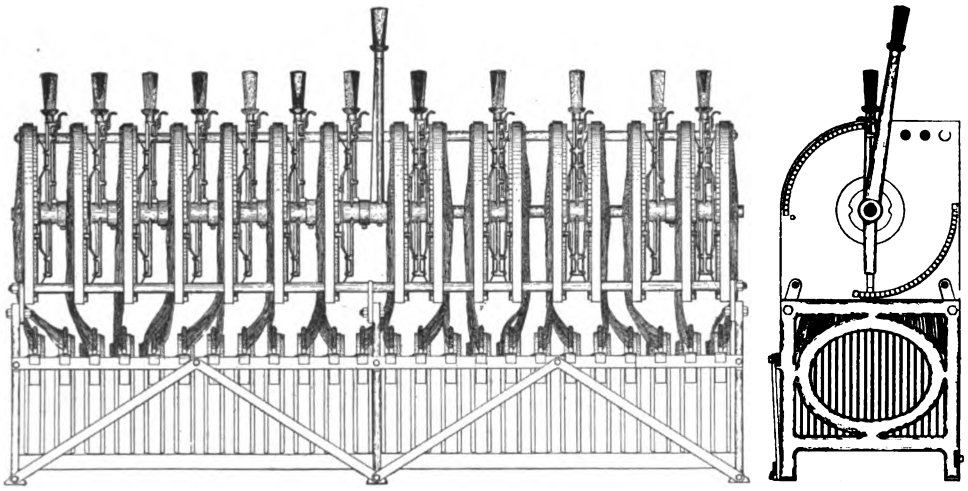
FIG. I.—FULLY EQUIPPED TRUCK FOR BROOKLYN BRIDGE CARS.


ELECTRO-MECHANICAL GONG.

THEATRE DIMMERS.

The progress of theatre lighting and the control of electric light for scenic effects is of like interest to the theatrical profession and constructors of theatre lighting plants. Among the recent improvements made in theatre dimmers is an interlocking switch system illustrated in the accompanying cut. Where several dimmers are used, a system of interlocking the switch handles, so that any or all of the dimmers can be operated by one central master bar, is indispensable.

The bank of theatre dimmers illustrated, built for one of the largest theatres in the country, is composed of four 3-wire dimmers and eight 2-wire dimmers, ranging in capacity from 40 lights to 200 lights each, a total of 1150 lights. The dimensions are 78 ins. × 37 ins. × 20 ins. exclusive of handles. The completed instrument is neat as well as compact and substantial, and fulfills the specifications of fire departments and insurance underwriters.


THEATRE DIMMER.

In addition to the above described large bank of dimmers the same manufacturers recently filled an order for a bank of 24 dimmers complete with interlocking switches. This bank has a capacity of 1480 lights, with dimensions 120 ins. × 37 ins. × 20 ins., exclusive of handles. The maximum height to top of master bar is 48½ ins.

Dimmers of any capacity from one light to 10,000 lights in any of a dozen different styles are made by the Iron Clad Rheostat Company, Westfield, N, J., the manufacturers of the type above described.

NEW ELECTRO-MECHANICAL GONG.

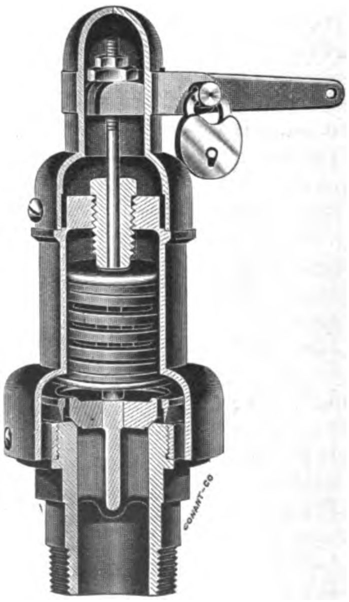
The new electro-mechanical gong, illustrated in the accompanying cut, is a decided departure from the usual types now on the market. The hammer is pivoted at the post, and when released it makes a full revolution; passing under the gong it is raised by an inclined plane, strikes the gong a powerful clear blow and drops to its normal position under the gong. After the first blow the armature remains close to the magnets, so that very little power is required to operate it, and very rapid blows may be struck.

The smaller sizes, 4 ins. to 8 ins., are encased in a polished wooden box with a nickel-plated front, to which is attached the entire mechanism of the bell. By unscrewing this front the whole bell may be removed from the case and the inner parts exposed. Lantern pinions and a very strong spring encased in "main spring box," are used. The larger sizes, 10 ins. to 30 ins., are mounted on a cast frame and entirely encased in a polished wooden box, the front of which can be removed, as shown in the illustration. This style is made to operate by either a spring or weight, and will strike about 500 blows to each winding. These bells can be arranged to continue striking single rapid blows until the circuit is broken. Being dust and damp proof they may be used in exposed places.

The bell described is made by Edwards & Company, 144th Street and Fourth Avenue, New York.

LOW PRESSURE POP SAFETY VALVE.

During the present year the Massachusetts State Legislature revised the engineer's license law, its new provisions as applying to low pressure steam boilers in residences, dwellings and apartment houses, permitting a licensed engineer to be dispensed with if the boiler carries "an improved device limiting the pressure carried to fifteen pounds per square inch." We illustrate herewith a


ASHTON LOW PRESSURE POP SAFETY VALVE.

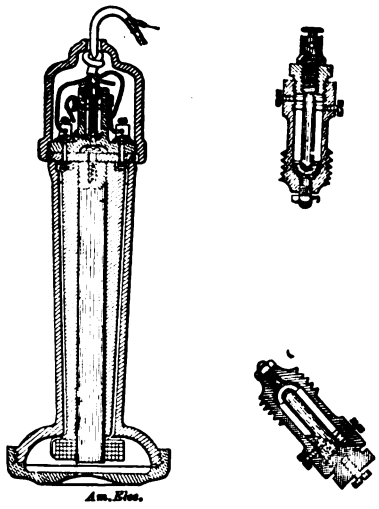
pop safety valve made to meet the requirements of the above mentioned law, and which has been accorded the necessary official approval.

The valve is made with an under discharge outlet, thus preventing dust or dirt getting to the interior. All working parts are of composition metal, and the spring of Jessop's steel. The lock-up attachment and trip lever prevent tampering and also make it possible to test the valve when desired.

The Ashton Valve Company, 271 Franklin Street, Boston, are the manufacturers of the valve described.

TELEPHONE SWITCH.

A patent has recently been granted to Elias E. Ries for a telephone switch, the principle of which is made clear in the accompanying illustration, which shows the switch applied to the ordinary telephone. As will be seen, the contact arrangement consists of a thimble of insulating material containing a globule of mercury. When the telephone is hanging vertically, the mercury closes the line-bell circuit, and when in natural position at the ear this circuit is cut out and the primary and secondary of the transmitter cut in. It is claimed that this device is entirely clear of all other telephone switch patents, and presents a number of advantages—among others greatly facilitating telephonic communication, as it is merely necessary when ringing up to tilt the telephone without removing it from the ear.



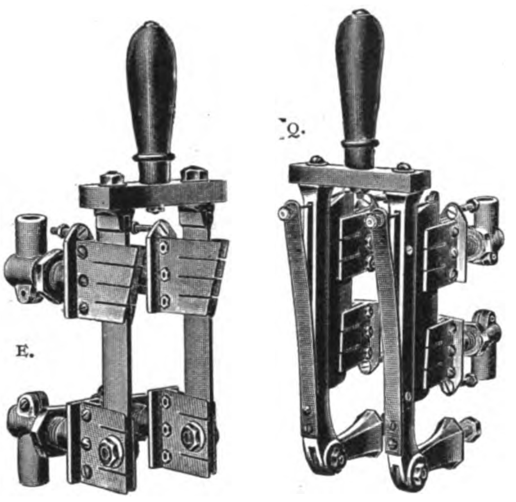
TELEPHONE SWITCH.

NEW KNIFE SWITCHES.

The demand for high grade knife switches has brought upon the market designs of various makers. The most recent are the type "E" and type "Q," manufactured by ths Western Electric Company, Chicago, and shown in the accompanying illustration. The contacts of these switches are all rolled tempered copper, and the greatest care in construction and design has been observed in order that the switches shall carry their rated capacity in amperes without showing any heating of the parts. In placing and fastening the jaws in position, they are not soldered, but bolted to the metal plates or lugs, as can be seen from the illustration. By this method the temper of the jaws is in no way injured, and they will always grasp the blade of the switch with an equal and unvarying contact which will not deteriorate with time. The hinge contact is made in the same way, and the bolt which passes through the hinge is provided with a lock nut, preventing any liability of loosening or poor contact at this point. The blades are of drawn copper, hand finished.

The base is extended for connections on the back of the board, and is secured in place by a lock nut. Swivel connections are provided, which will admit of the circuit wires being brought into the switch from any direction. The switches are all made to gauge, and any repair part can be obtained and a damaged part replaced in a few moments.

The type "E" is for station and switchboard work, being of the regular jaw pattern. The type "Q" is essentially the same as type "E," with the addition of a quick-break spring, and is especially approved by the Underwriters for an entrance or service switch for motor work, constant potential arc or incandescent lighting.



NEW KNIFE SWITCHES.

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PERSONAL.

Mr. G. L. Foote, senior member of the new firm of Foote, Pierson & Company, which has recently purchased the manufacturing department of The E. S. Greeley & Company, has probably done more experimental work for inventors than any other electrician in the world, particularly with respect to telegraphic and telephonic apparatus and the more delicate kind of electrical mechanisms. During the 25 years he was connected with the manufacturing department of Tillotson and Greeley Companies, he had a large share in perfecting many electrical inventions of note, and many years ago acquired a wide reputation among inventors and experimenters as possessing extraordinary skill in transforming small models offered him into practical and commercial apparatus. In one instance that came under the writer's notice, a model weighing 30 or 40 lbs. and including a complicated system of weights, wheels, cams and levers, was transformed into a simple piece of mechanism weighing but a few pounds and containing not a half dozen parts, all told, in which shape it is now in commercial use.

◆

NEW BOOKS.

NATIONAL ELECTRIC LIGHT ASSOCIATION; Nineteenth Convention. New Yoik: Published by Order of the Executive Committee. 446 pages, illustrated.

The current volume of the Proceedings of the National Electric Light Association is one of the most creditable yet issued, both with respect to the matter contained and the execution. The papers by Mr. John F. Kelly on "Some Account of the Distribution of Light and Power by Alternating Currents" are contributions to electrical literature of permanent value, while that of Mr. L. A. Ferguson on "The Commercial Value of Acetylene Gas" remains yet the best discussion on the vexed question of the cost of production of calcium carbide.

TRANSFORMERS FOR SINGLE AND MULTIPHASE CURRENTS. A Treatise on their Theory, Construction and Use. By Gisbert Kapp. New York: The Macmillan Company. 241 pages, 133 illustrations. Price, $1.75.

The need of an authoritative practical work on transformers has been long felt, and the electrical public is to be congratulated that Gisbert Kapp took upon himself the task of supplying the want. The present volume can be numbered among the most important technical electrical treatises thus far published and in no respect falls short of the high standard set by Kapp in his previous works. It is distinctly practical in its treatment of the subject, which is thoroughly considered from every standpoint. The small amount of mathematics necessarily contained need not deter the non-mathematical reader, as he will find the practical statements which accompany such matter generally sufficient for his purpose.

◆

TRADE PUBLICATIONS.

Conduits. In a very handsome little pamphlet John T. McRoy, Chamber of Commerce Building, Chicago, describes and illustrates the various forms of McRoy vitrified terra cotta conduit. Information in concise form is contained on the method of installing and jointing the conduit.

X-Ray Apparatus. In a handsome pamphlet with this title, the Central Electric Company, 173 Adams Street, Chicago, describes a number of complete equipments for taking Röntgen radiographs, including induction coils, interrupter, Röntgen tubes. fluoroscopes and storage batteries. The pamphlet is illustrated with some excellent half-tone reproductions of radiographs.

Circuit Fittings. The Bossert Electric Construction Company Utica, N. Y., in a 32-page catalogue describes and illustrates 15 different types of distributing boxes, branch circuit boxes, etc., for interior wiring. To the electrician not acquainted with the latest practice in such fittings, this pamphlet will prove of much interest, the descriptions accompanying the cuts being in considerable detail.

Electric Heaters. The Globe Electric Heating Company, 141 N. Twelfth Street, Philadelphia, has issued a new catalogue describing and illustrating the various forms of electric heaters which it manfactures. The heaters illustrated are artistic in appearance. The Globe Company makes a specialty of this point, supplying heaters to harmonize with any particular design of fixtures or decoration.

Enclosed Arc Lamps. The Ajax enclosed arc lamp is the subject of a pamphlet issued by Pomeroy, Woltmann & Company, 43 Cortlandt Street, New York, in which the principles and advantages of this type are pointed out and its mechanism illustrated. It is claimed that the Ajax lamp entails a direct saving in the labor of trimming of 93 per cent. over open arc lamps of the ten-hour class, and 94 per cent. in cost of carbons.

Holophanes. Prof. A. Blondel, of Paris, one of the great electrical authorities of the world, gave the name of "holophane," (meaning wholly luminous) to an ingenious system of enclosing globes of his invention, whereby light from a small source is so perfectly diffused as to make the globe appear to be the luminous source. The Geo. A. Macbeth Company, Pittsburgh, Pa., are the American manufacturers of holophanes, which they describe and illustrate in a pamphlet that may be obtained upon application.

Walker Company Circulars. Among the most valuable trade publications are the technical circulars issued from time to time by the Walker Company, Cleveland, O. The circulars, indeed, have rather the character of technical monographs than trade publications, giving as they do detailed and carefully written and illustrated descriptions of new types of apparatus and appliances. Among recent additions to the list are one on street car motors, in which the Walker motor is illustrated and described in close detail, and another on switchboards and instruments, which will give a better idea of modern switchboard design than may be found in any electrical book publication.

Electric Light and Street Railway Supplies. The Electrical Engineering & Supply Company, Syracuse, N. Y., has issued a substantial 116-page, "1897" catalogue (No. 7), which thoroughly illustrates and describes the large line of electric light and street railway supplies of its manufacture. The largest portion of the space is devoted to jack-knife switches, switchboards and switchboard fittings; no less than 50 pages are necessary for this purpose, most of which is given up to switches alone, 22 types being illustrated. Porcelain electric light fittings and incandescent lamp switches and sockets of all varieties are also shown in great variety. As an illustrated epitome of the latest practice in electrical fitting, this catalogue will be useful on the desk of every electrician.

◆

BUSINESS NEWS.

The Hercules Float Works, Springfield, Mass., have just issued a new catalogue and price list of their seamless copper floats and air chambers.

The Western Electric Company, Chicago, reports a very large demand for the Sumbeam lamps, especially for the 2, 4 and 6 CP. lamps. Large orders have been filled for use in sign and decorative work.

Charles Wirt, 1028 Filbert Street, Philadelphia, has appointed as Southern agents the Electric Supply & Construction Company, Savannah, Ga., which will carry a full stock of Wirt brushes and supply the Southern trade.

An Arc Lamp Contact. After a spirited contest, Pomeroy, Woltmann & Company, 43 Cortlandt Street, New York, were awarded the contract to furnish 64 of their Ajax arc lamps for the new Ninth Regiment armory on Fourteenth Street, New York.

Younglove & Gere, 312 E. Genesee Street, Syracuse, N. Y., manufacturers of the Cherry-Younglove ventilated dynamo brush, are busy filling orders received not only from this, but from foreign countries. So positive are they of the efficiency of their product, that brushes are sent on trial to responsible parties.

The Baechtold & Parker Electric Company, 79 Washington Street, Brooklyn, is the subject of an appreciative article in the New York *Mercantile & Financial Times*. This firm has acquired an enviable reputation for the high character of its workmanship, and well merits the commendation bestowed.

Goldmark & Wallace, 29 Chambers Street, New York, who carry a complete and well assorted stock of the well known Koch German dynamo brushes, are having greatly increased sales recently, owing to the fact that users find that they are able to promptly fill all orders for brushes of any sizes or for any quantity, thus avoiding the previous delay in having foreign orders filled.

Ira J. Strong, 267 Asylum Street, Hartford, Conn., is installing for the Salmon River Electric Light Company, at Leesville, Conn., a 143-HP Trump water wheel, the power from which will be used for lighting and power in Moodus and East Hampton, Conn. Over 1000 lights have been contracted for and it is expected that within a short time power can be transmitted to both Middletown and Portland, some twelve miles from Leesville. The plant can be increased to 1500 HP.

Eyanson & Armpriester, 123 N. Third Street, Philadelphia, Pa., have an order for installing the switchboard for the Mexican International Railway of the City of Mexico, and another for a 4000-ampere board for the Continental Brewing Company. They have just finished a board for the Lyondale Bleach, Dye & Print Works. This latter board is of 5000 amperes capacity, the plant using the electrical system of power distribution. The same company is building a switchboard for a Japanese government lighting plant at Yokohama, Japan.

Hugo Reisinger, of No. 38 Beaver Street, New York, reports an extraordinary increase in the business for the "Electra" high grade Nuernberg carbons. He recently received a letter from a leading electric lighting station repeating the order with the statement, "The shipment furnished us was so far superior to anything heretofore used by us, that we have concluded to adopt the "Electra" carbons exclusively for our arc lighting in the future." The above letter is said to be one of the many testimonials which Mr. Reisinger has received, and certainly speaks very highly of the merits of the "Electra" carbons with which he supplies the trade.

The Western Electric Company, of Chicago, has been given the agency for the complete line of Lundell power motors, which range in size from one-sixteenth of a horse power up to any size required. These motors, as is well known, are completely encased and generally regarded among the trade to be one of the best motors on the market. They can be readily connected to printing presses and ventilating fans, and are also used for blowing large organs. Wherever electric power is desired, these motors are especially applicable. These motors will be kept in stock, in Chicago, subject to immediate delivery,

An Engine for China. The American Engine Company, of Bound Brook, is about to ship one of its new American-Ball engines to the Chinese Government, to be used in driving machinery for the coinage of silver. Among other shipments of engines during the month of November were machines to Leavenworth, Kan., St. Paul, Minn., and Long Island City. Shipments of electrical machinery during the same month were dynamos of 18, 25 and 50 KW, and motors as follows: two of 50 KW and one of 25 KW, five of 12 KW and one of 5 KW—the states represented being New York, Massachusetts, Illinois, Minnesota, Georgia and Missouri, and the District of Columbia.

Foote, Pierson & Company have purchased the entire manufacturing department formerly owned and operated by The E. S. Greeley & Company, 5 and 7 Dey Street, New York, and have removed the same to 82 and 84 Fulton Street, where the manufacture of all electrical instruments and supplies manufactured by the Greeley corporation will be continued, particular attention being given to the designing and building of special electrical apparatus. The members of the new firm had been connected with L. G. Tillotson & Company and The E. S. Greeley & Company in the above department for the past 25 years, during that long period gaining an experience which, in the varied character and extent of work, is probably unrivalled in this country.

Reliability of Wattmeters. We learn that within the past month a series of important tests have been made to determine the accuracy of the Thomson recording wattmeter under certain conditions. The tests were carried out to verify sundry criticisms to the effect that on rapidly fluctuating loads, the meter was derelict in its accuracy—especial reference being made to elevator work. The object of the tests was the determination of the mean error under maximum conditions of fluctuation, and the result was gratifying from the standpoint of the meter. It was found that the maximum of error, introduced by this character of load—that is, under the worst possible or maximum condition of fluctuation—did not exceed six-tenths of one per cent., a percentage materially reduced under conditions less than the maximum.

Five Successful Years. The Electric Appliance Company has just completed its fifth business year, and is congratulating itself on the results. The company began business five years ago, at its present location, occupying a part of the first floor of the building at 242 Madison Street, Chicago. Its business has increased, demanding greater facilities from time to time, until now it occupies the entire building, and has a large basement, and the three large upper floors filled with valuable stock, and is one of the largest electrical supply houses in the United States. Its supply line is very large and complete in every respect, and the line of specialties carried is perhaps the most desirable controlled by any one supply house in the country. Its facilities for transacting a large volume of business, to the satisfaction of the trade, and to their own profit is unsurpassed.

The Bryant Electric Company Branching Out. The Western supply trade will note with interest the establishment of a branch factory at East Liverpool, O., by the Bryant Electric Company, manufacturers of the well known "Bryant specialties." The Bryant Company states that it is not its intention to manufacture its complete line of supplies at East Liverpool, but for the present will confine its work at that point to Sawyer-Man cut-outs, 500-volt railway blocks and the well known K. W. ceiling rosettes. The manufacture of other specialties will, however, be added as necessity demands. The largely increasing Western trade of this company has made the move outlined above necessary, and the advantages resulting to the supply trade in the way of early deliveries and reduced freight rates are very apparent. The Bryant Company will establish no business office at East Liverpool, and all correspondence should be addressed as formerly, either to its Western office at Chicago, or the main office at Bridgeport, Conn.

Interior Conduit and Insulation. The trade will be interested to know that the Western Electric Company, of Chicago, has been given the agency for the products of the Interior Conduit & Insulation Company, of New York. All brass armored and iron armored conduits, elbows, couplings, fittings, etc., will be carried in stock in Chicago, and unusual facilities will be given to all jobbers and contractors for obtaining this material at the lowest prices. The Interior Conduit Company has just brought out a special conduit which it claims is much superior to anything which has ever before been placed upon the market, and it has not only increased the excellence of this material, but has very materially decreased the price. The Western Electric Company is prepared to furnish new prices upon application. Coupled with this agency, the Western Electric Company has also secured the agency for a full line of standard, iron-armored, slate-lined, panel, distributing, fuse, main, and feeder terminals; also branch junction boxes. These boxes are specially designed and each box can be used on either two or three-wire system.

The Ohio Electric Works. At this season the mind of the dealer naturally turns to novelties, and as the Ohio Electric Works, of Cleveland, are the leaders and headquarters for supplies in this line, a word about this concern and its products will be interesting. In this attractive branch of the science, as in the other branches, the leaders are young men. Mr. Albert C. Fletcher, the senior partner, has been engaged in electrical pursuits for the past twenty years, and his inventions have been phenomenally successful—electrically and commercially. The sale of the electric light for neckties has been simply wonderful since its reduction to a popular price, and the bicycle electric light made by the Ohio Company is the only one left in the field, of all that entered last spring. This successful light for the wheel will lead them all the coming season, as every part has been perfected and the price so cheapened that the cheap oil lights will be relegated to the ash heap in the spring. All who see the new Ohio lights are emphatic in the belief that electricity is the only thing intended for light on the wheel. Other inventions, such as cap lights for bands, miners and clubs, miniature lamps, small motors, etc, are illustrated in the company's catalogue and show the novel applications of the current in all branches of the science. The new electric student's lamp deserves special mention. Mr. J. W. Hencke, the junior partner, was for eleven years with the Standard Oil Company, but on account of the growth of the business of the Ohio Electric Works was induced to sever his connection with the Standard and devote his time to the financial part of the business, and his success is attested in the growth and success of the concern.

◆

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Write S. K. Hooper, G. P. & T. A. Denver, Colorado, for illustrated descriptive pamphlets.

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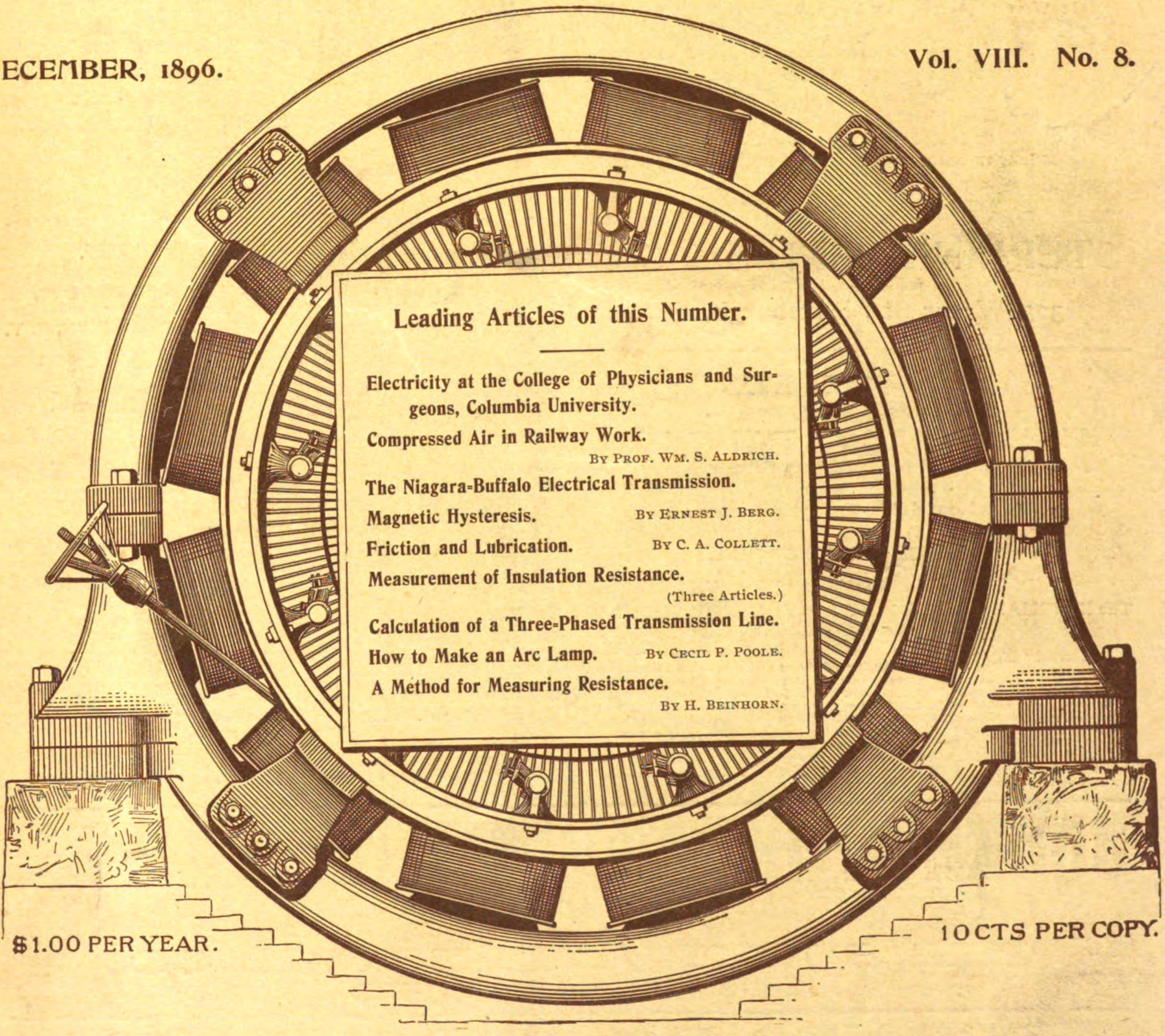

Leading Articles of this Number.

Electricity at the College of Physicians and Surgeons, Columbia University.

Compressed Air in Railway Work. By Prof. Wm. S. Aldrich.

The Niagara-Buffalo Electrical Transmission.

Magnetic Hysteresis. By Ernest J. Berg.

Friction and Lubrication. By C. A. Collett.

Measurement of Insulation Resistance. (Three Articles.)

Calculation of a Three-Phased Transmission Line.

How to Make an Arc Lamp. By Cecil P. Poole.

A Method for Measuring Resistance. By H. Beinhorn.

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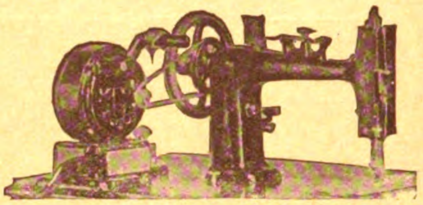

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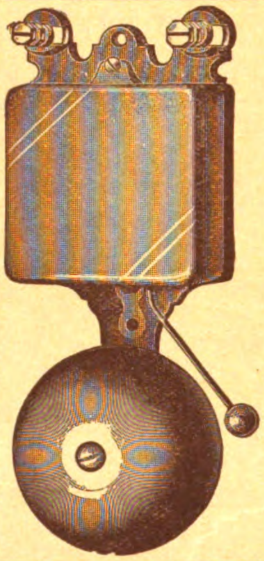

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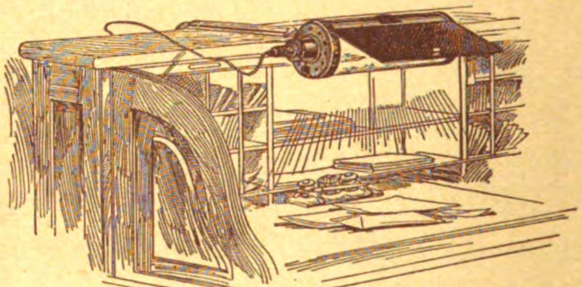

IT has been tried for three years and has not been found wanting. Users from Maine to California testify to its worth. No HIGH PRICED CANDELABRA LAMPS to be renewed. .. ..

The KINSMAN DESK LIGHT is made for ANY STANDARD LAMP.

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Kinsman Desk Light, Nickel Plate or Polished Brass, -	**$6.00**
Kinsman Desk Light, Dark Green Enamel, Gold Stripings,	**3.75**
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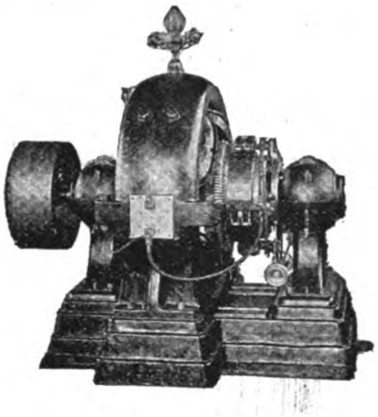

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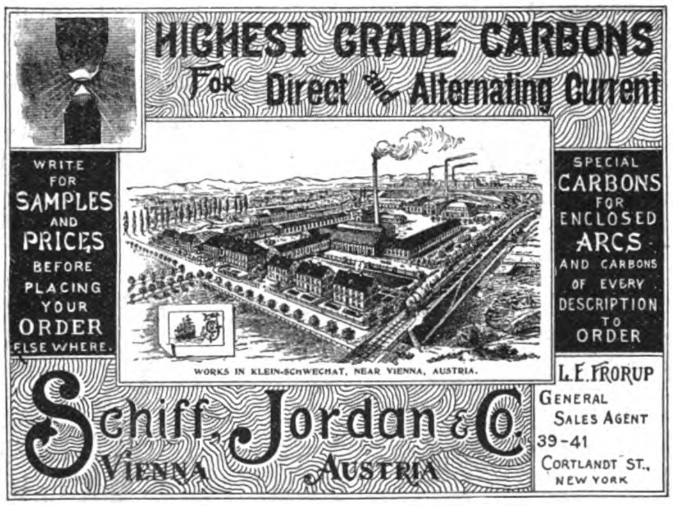

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No chance for the rods to jam. No parts to be continually renewed. Has a finer adjustment than any other clutch, and consequently a saving of current is the result. Can be applied to Brush as well as T.-H. lamps.
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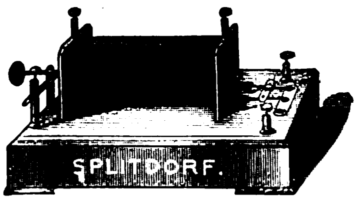

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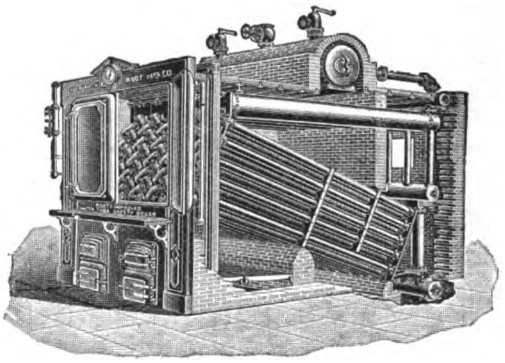

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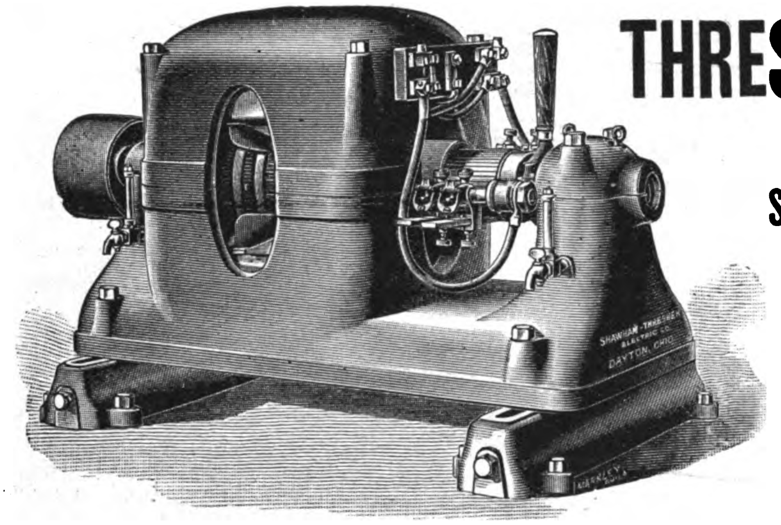
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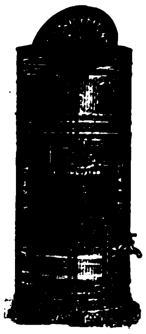

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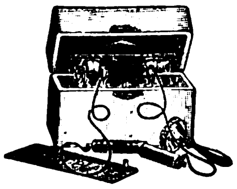

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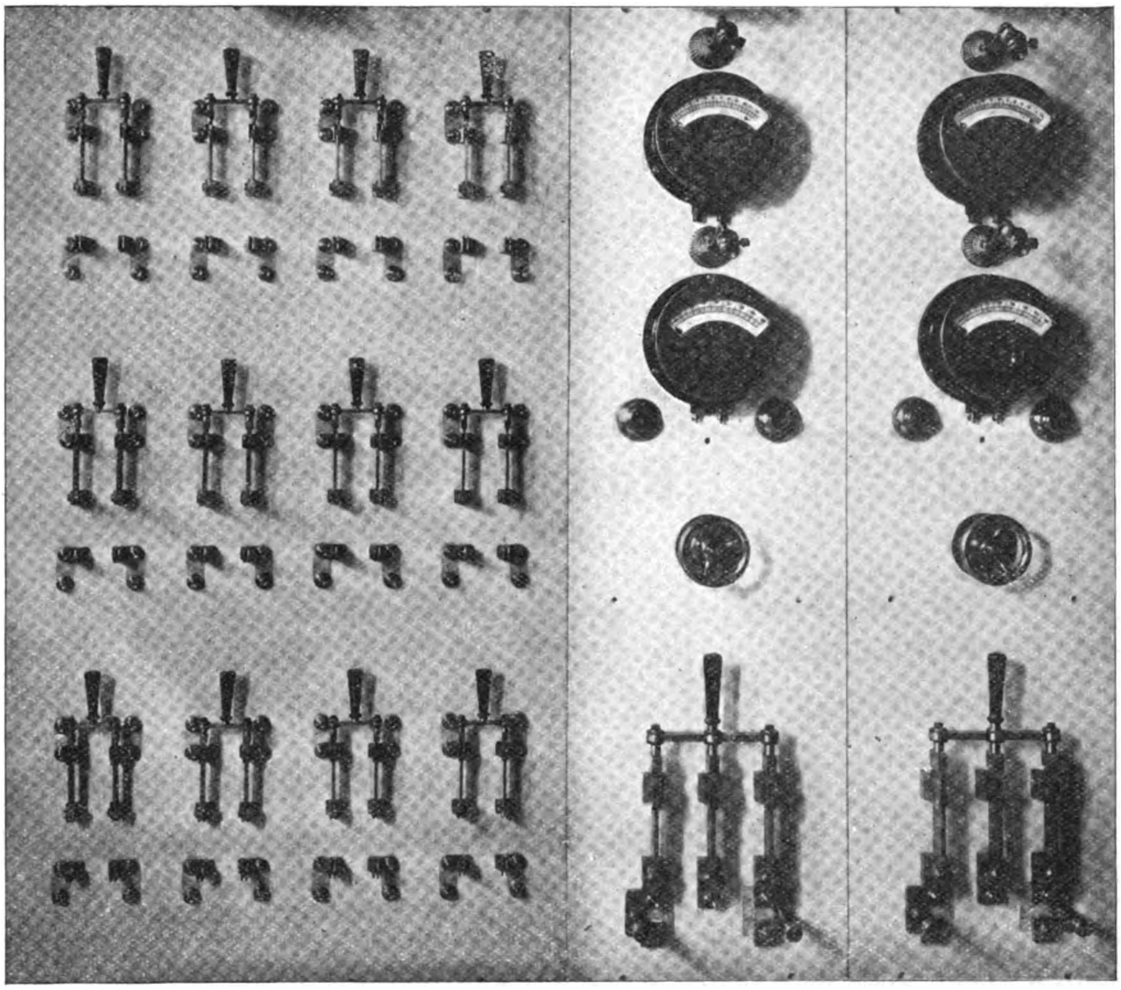

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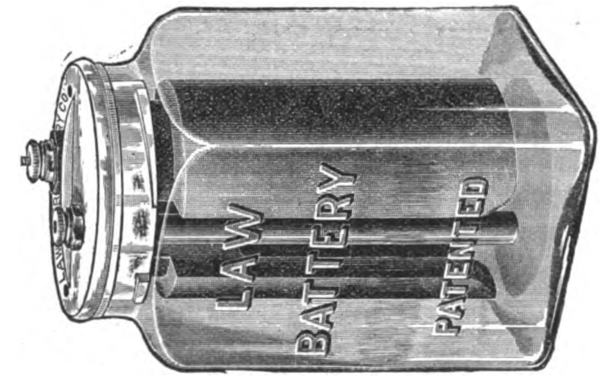

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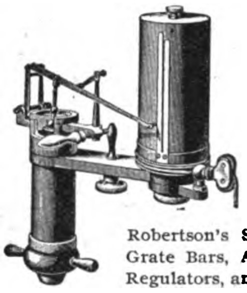

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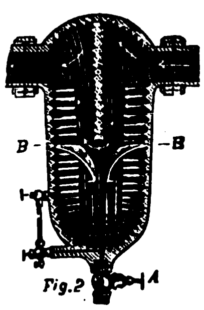

Fig.2

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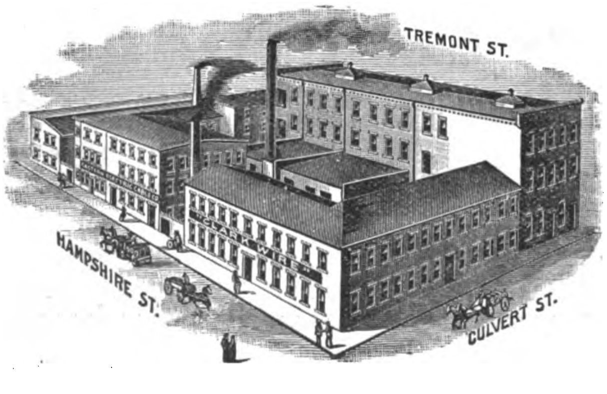
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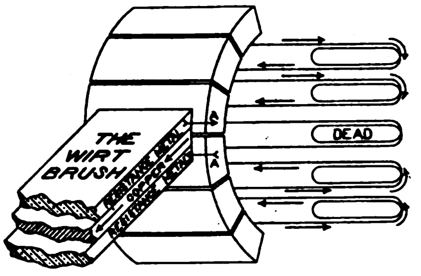

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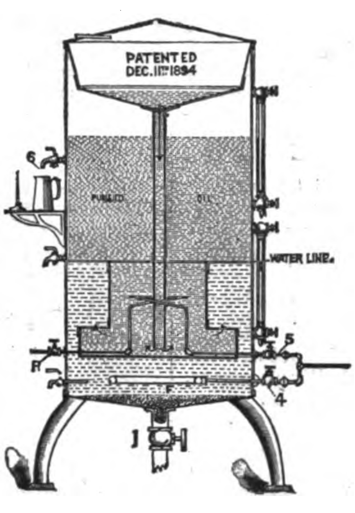

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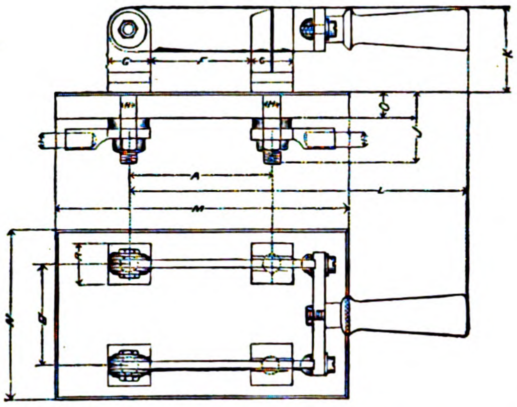

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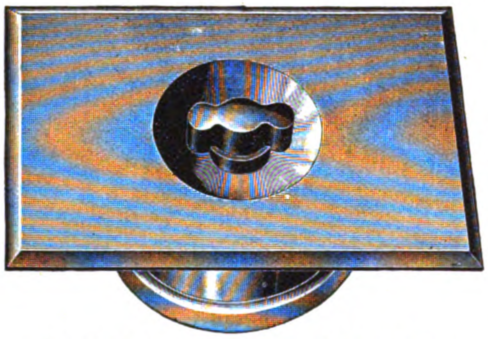

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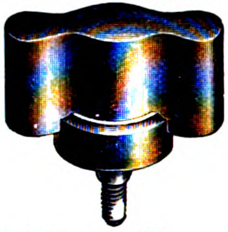

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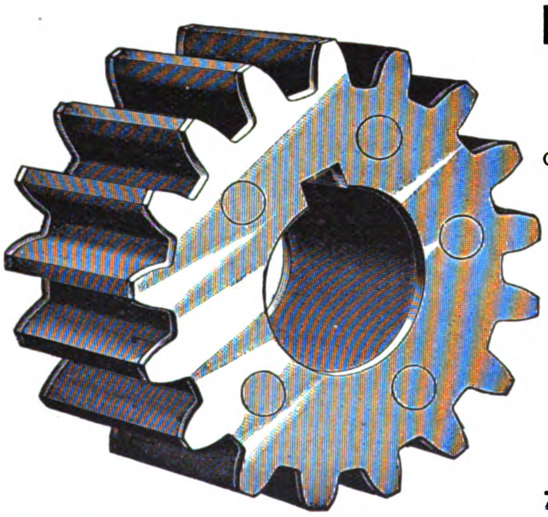

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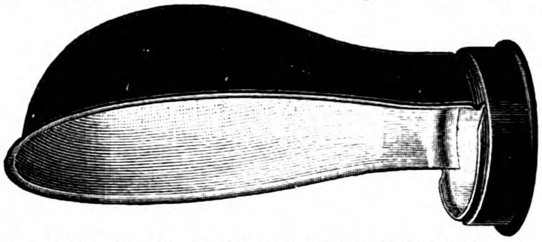

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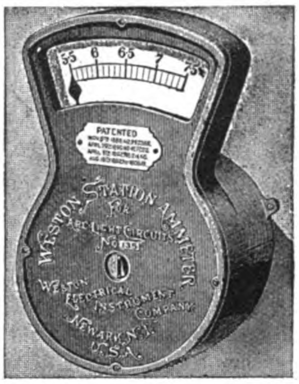
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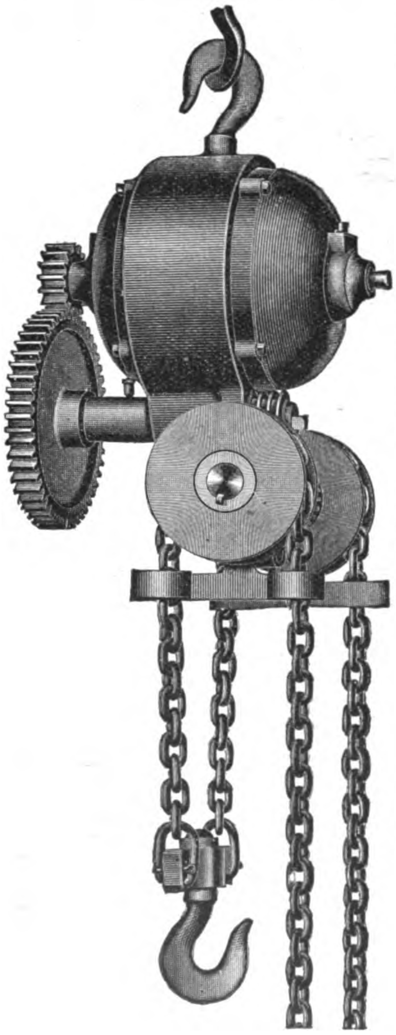

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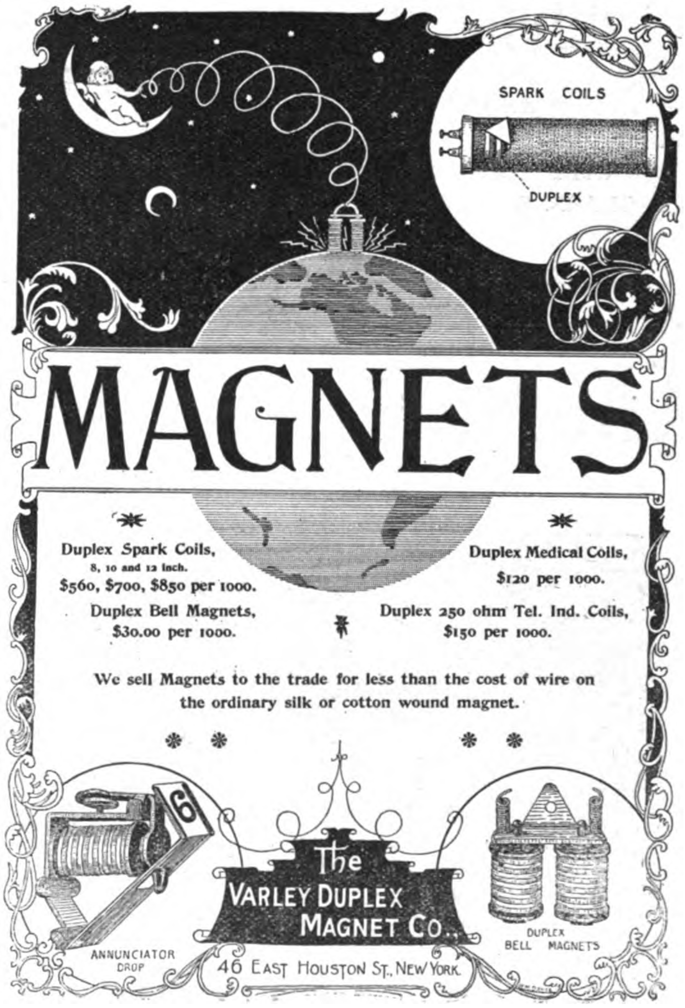

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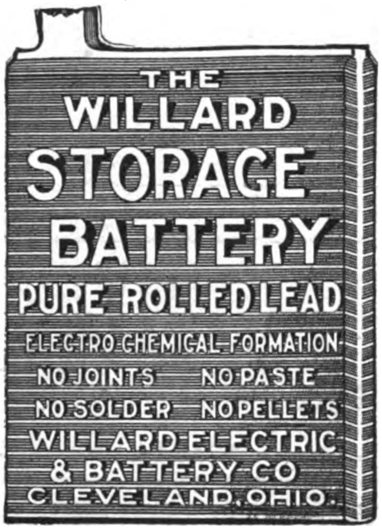
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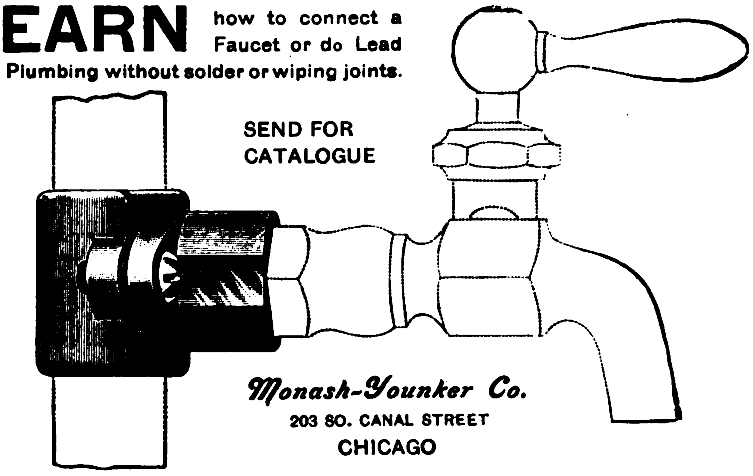
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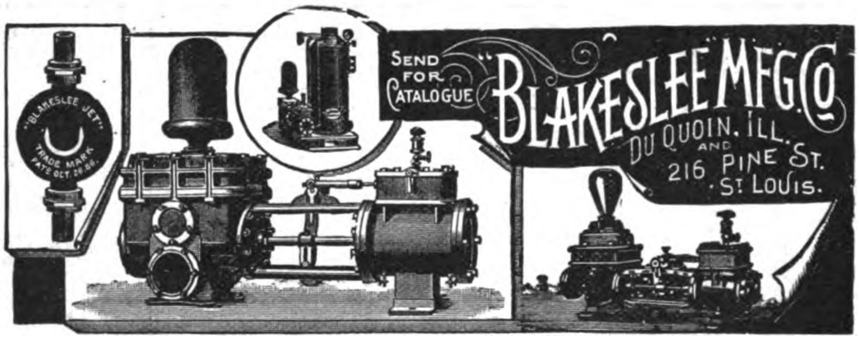
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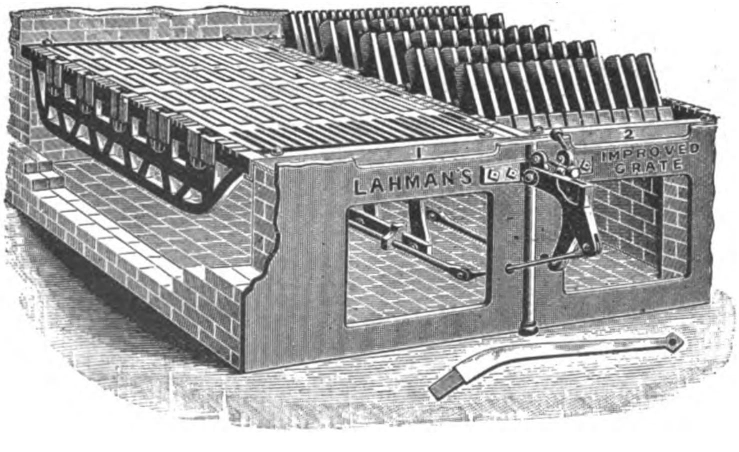

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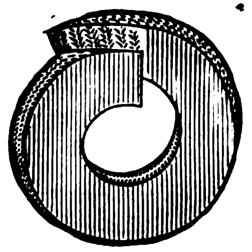

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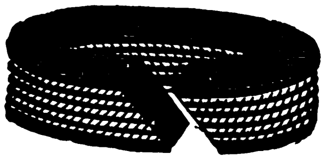

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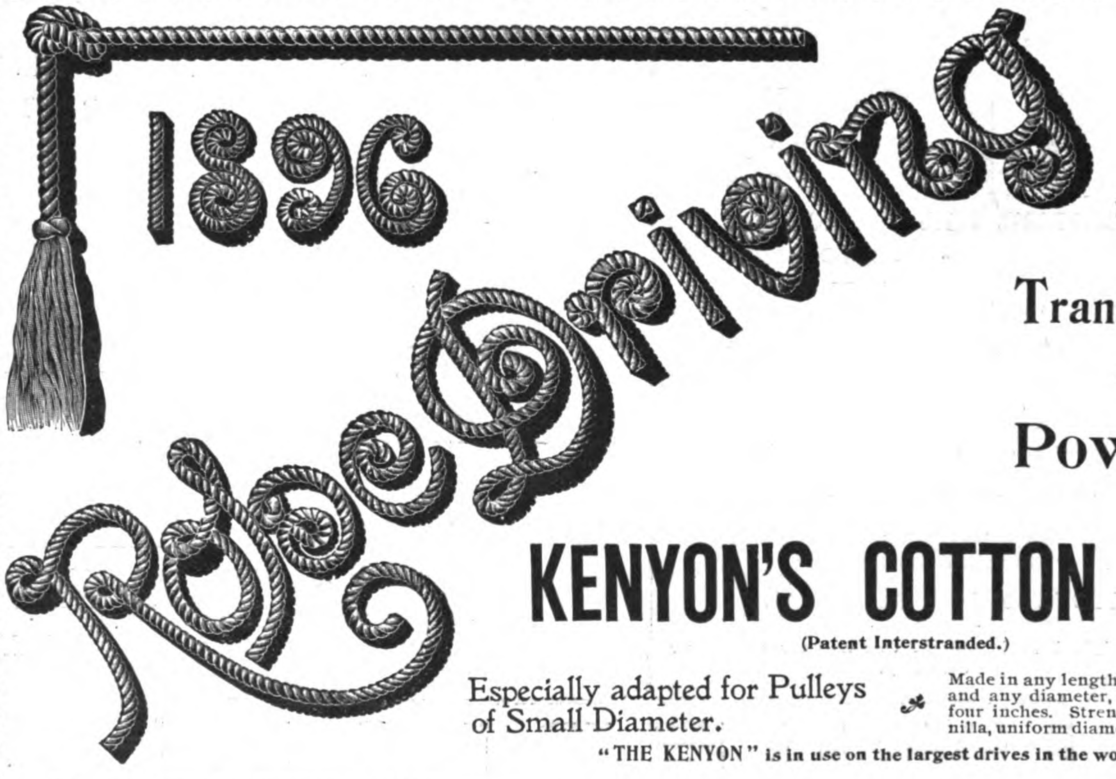

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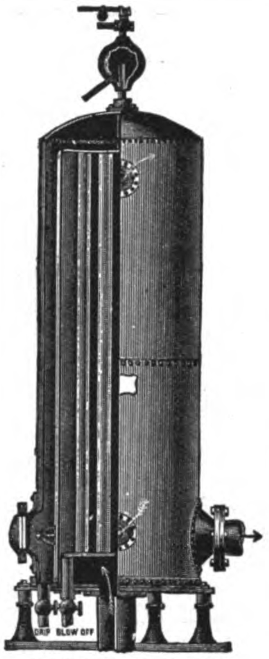

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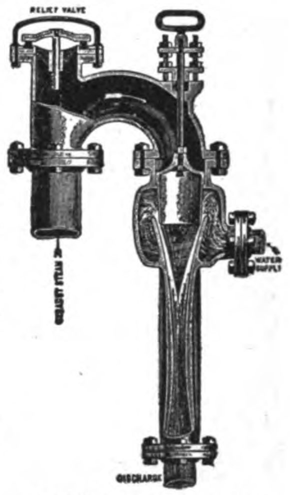

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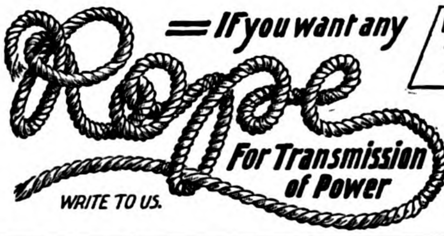

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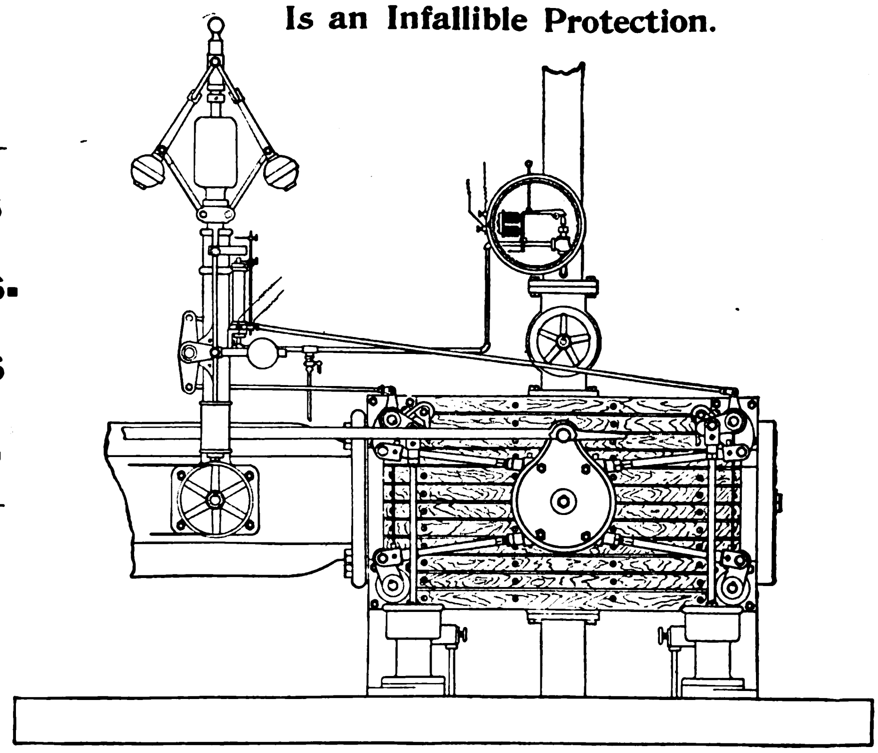

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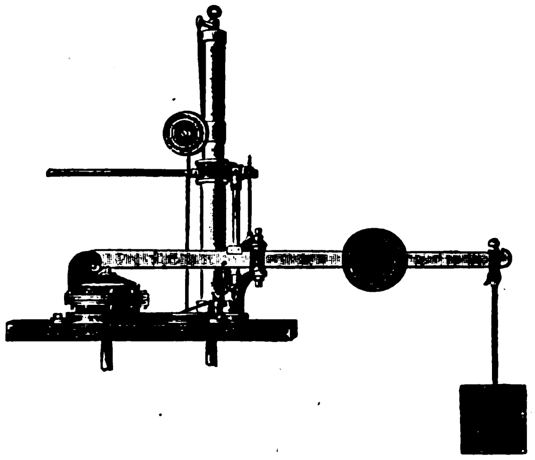

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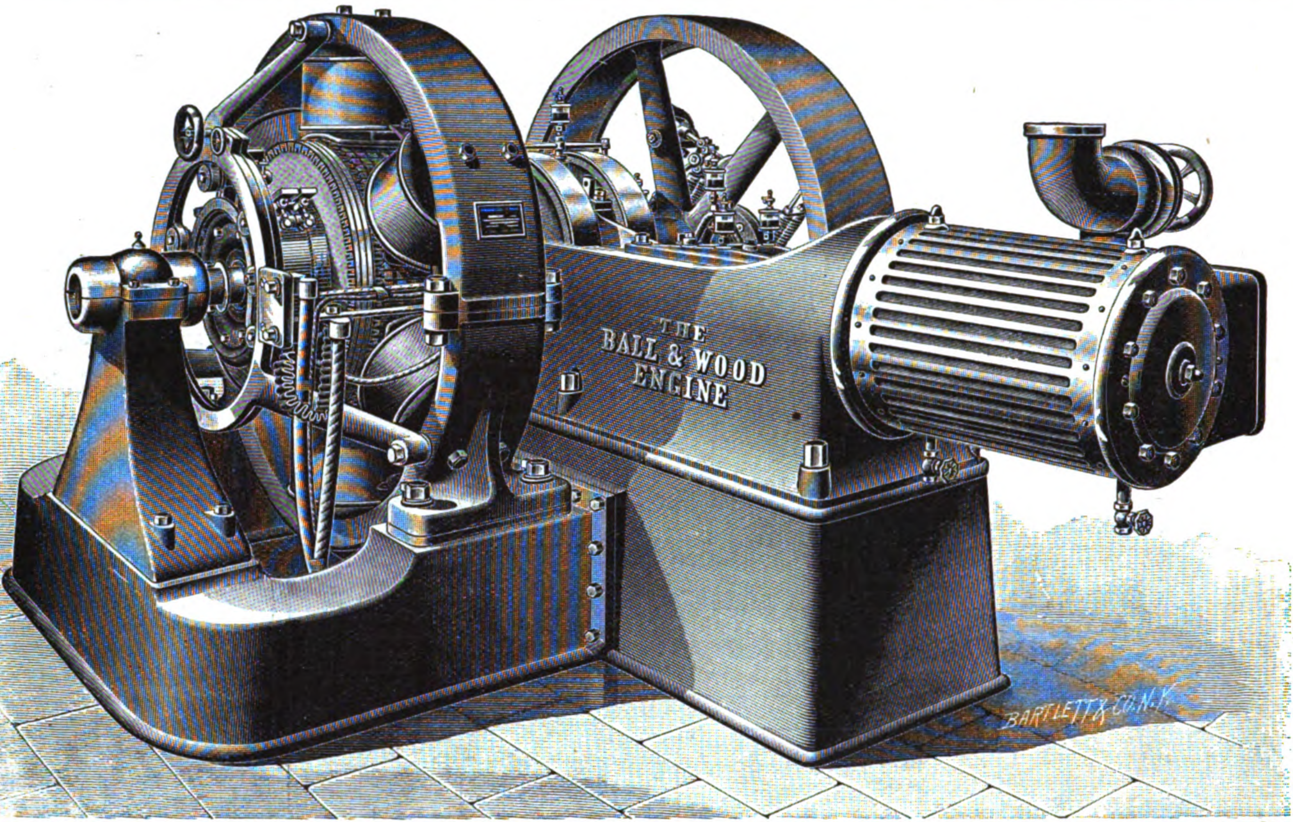

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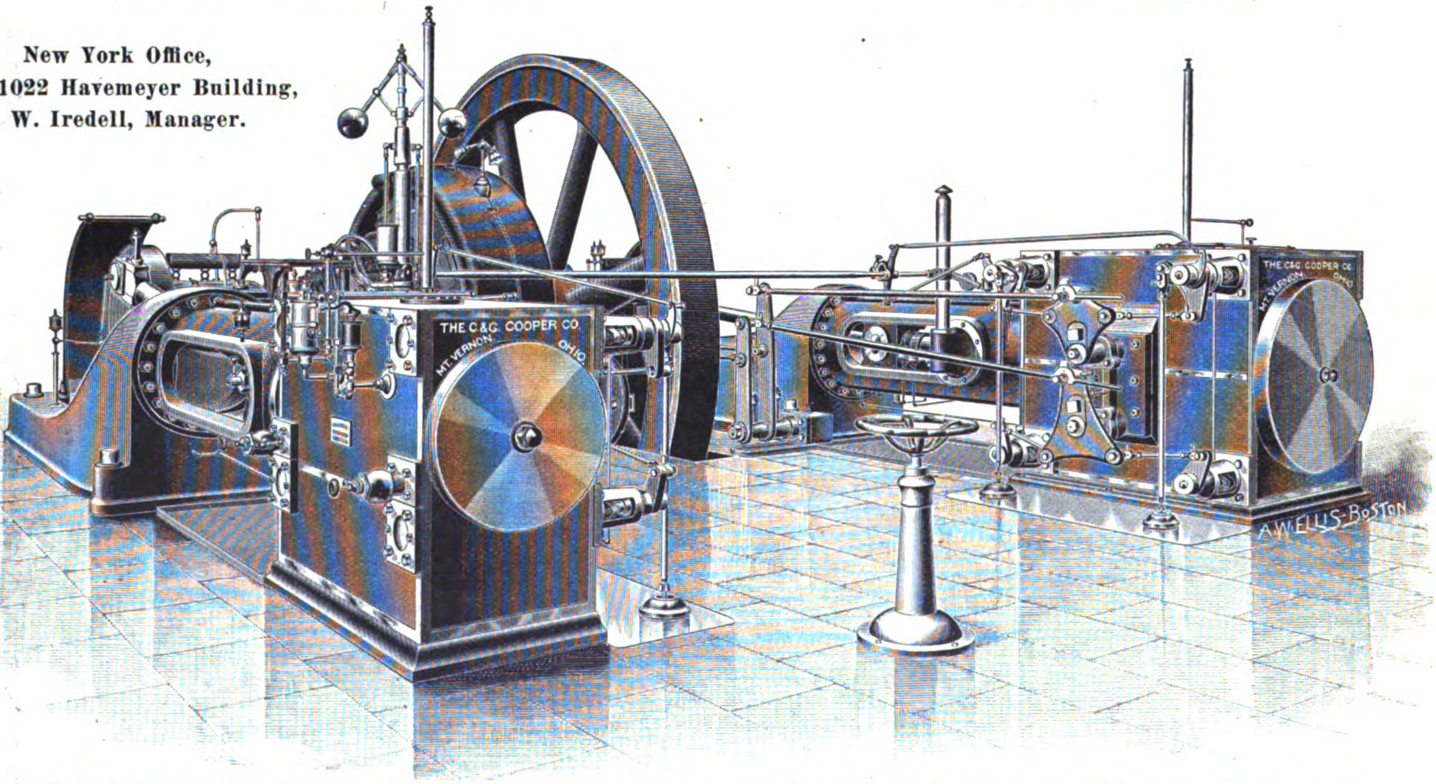

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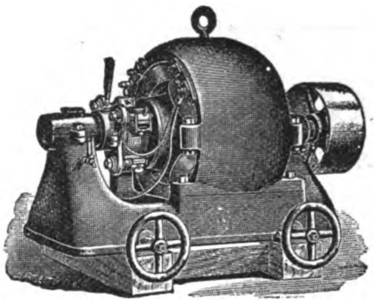

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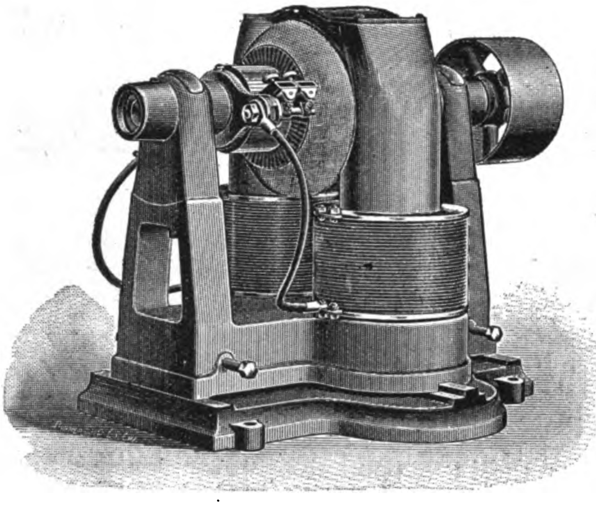

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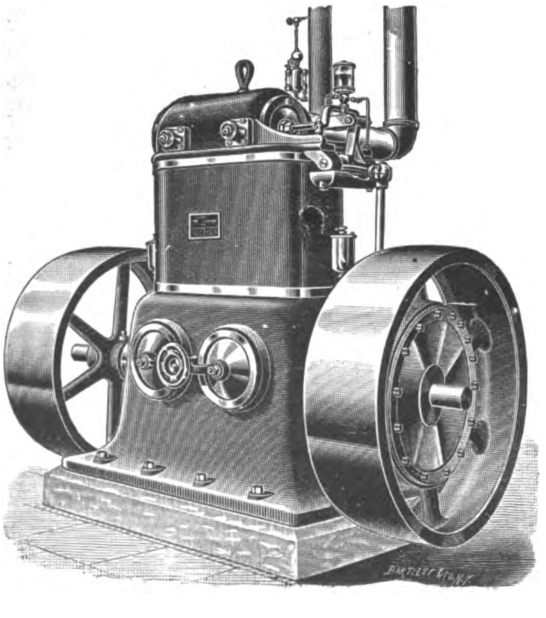

The business situation throughout the country on the first of October, was undeniably bad.

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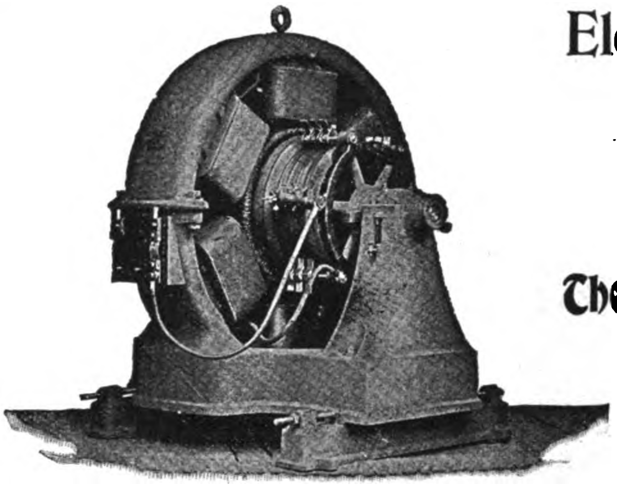

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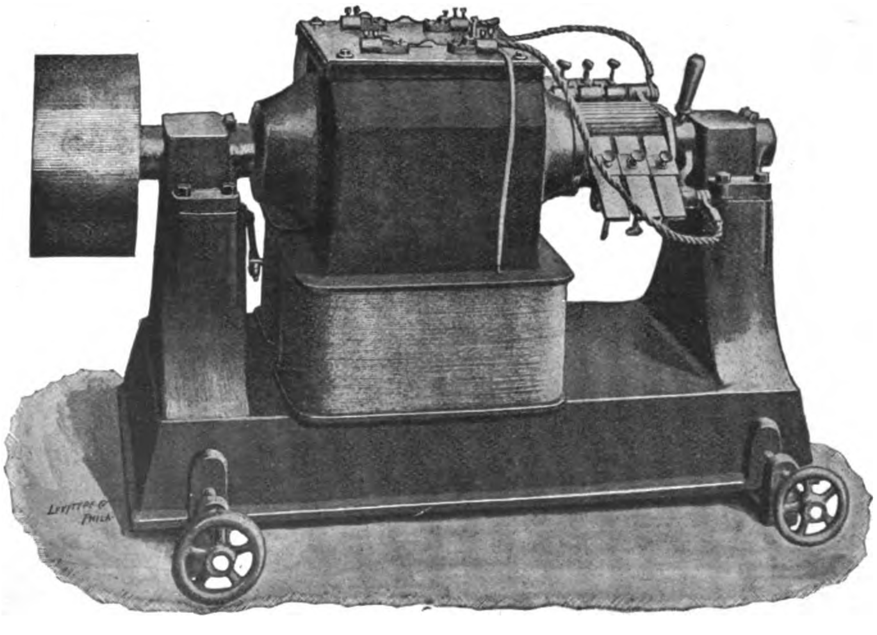

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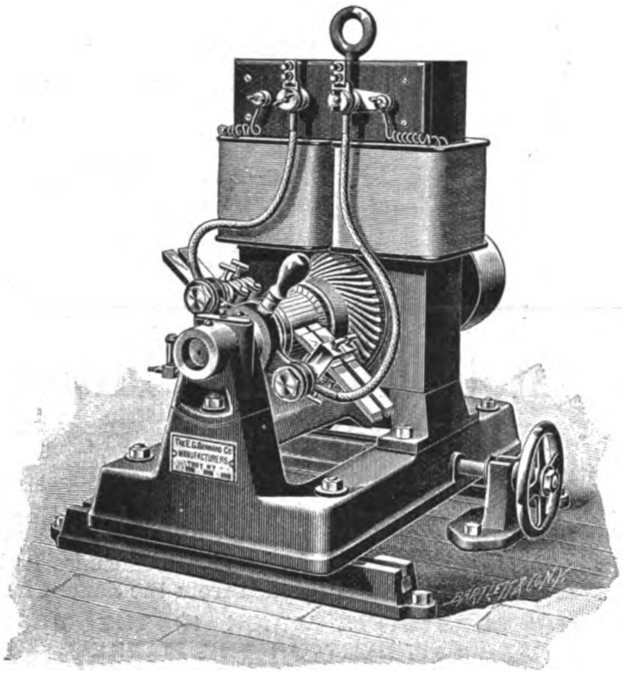

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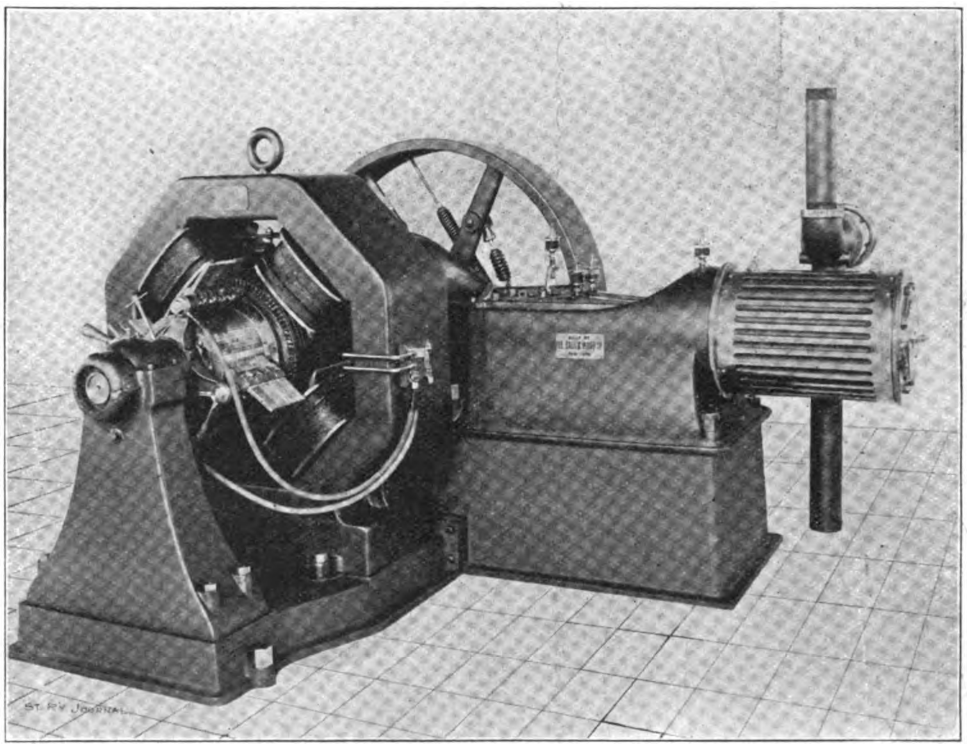

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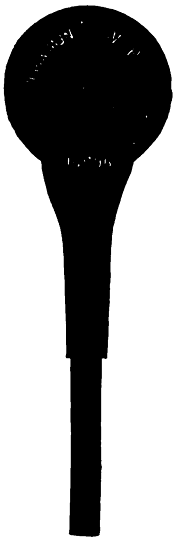

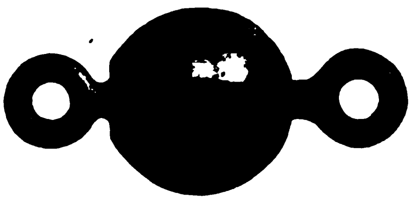

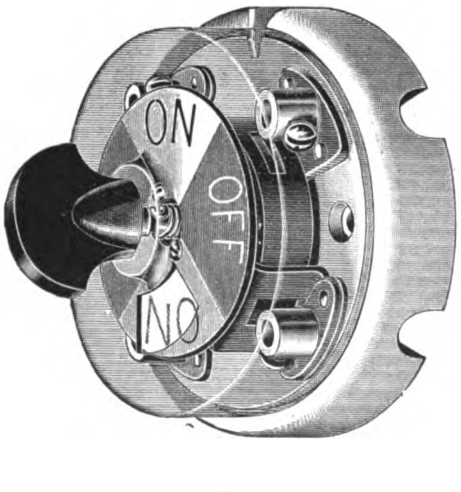

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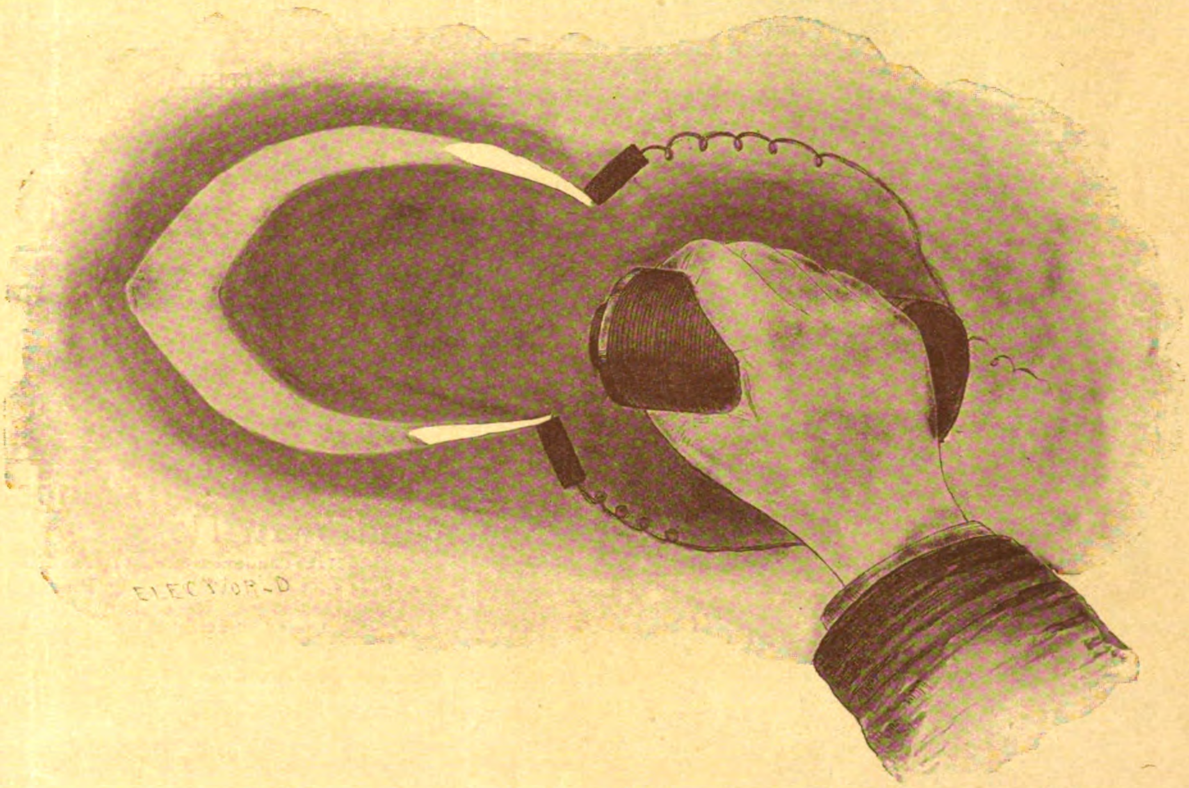

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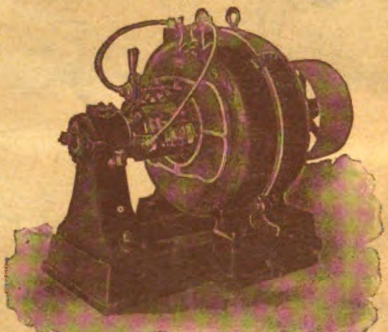

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